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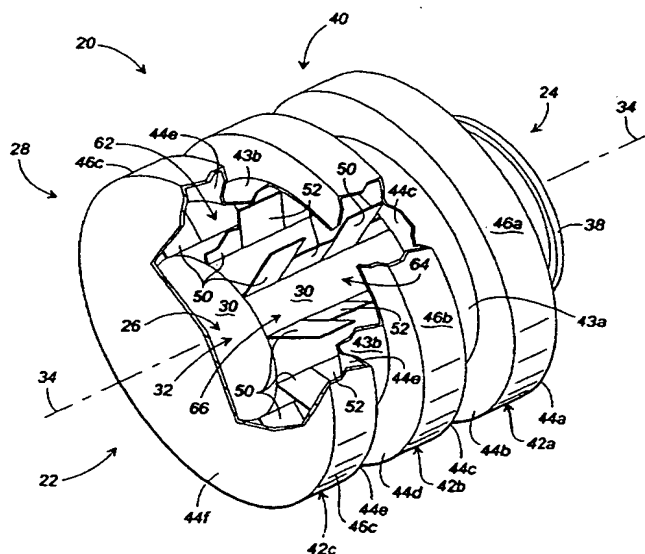
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- (71) Applicant: PERFORMANCE CONTRACTING, INC.  
[US/US]; 4025 Bonner Industrial Drive, Shawnee, KS  
66226 (US).
- (72) Inventor: HART, Gordon, H.; 11967 West 66th Street,  
Shawnee, KS 66216 (US).
- (54) Title: SYSTEM STRAINER WITH AN INTERNAL CORE TUBE
- (74) Agents: ISAF, Louis, T. et al.; Womble Carlyle Sandridge  
& Rice, P.O. Box 725388, Atlanta, GA 31139-9388 (US).
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(57) Abstract: A suction strainer including a hollow internal core tube and an external filtering structure built around the internal core tube. A plurality of flow or core openings are defined through the core wall of the internal core tube core. In some cases the flow openings through the side wall are constructed and arranged such that there is somewhat less open area near the downstream end than the upstream end of the internal core tube, and the amount of open area tapers between the upstream and downstream ends. As a result, when liquid is drawn into the internal core tube through the plurality of openings, a substantially uniform inflow distribution may be defined along substantially the entire length of the internal core tube. The internal core tube further functions as a rigid structural support for the external filtering structure.

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*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

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10        **SYSTEM STRAINER WITH AN INTERNAL CORE TUBE****CROSS REFERENCE TO RELATED APPLICATIONS**

      This application is a continuation-in-part of application Serial No. 09/137,395, filed August 21, 1998, which is a continuation of application Serial  
15    No. 08/904,604, filed August 1, 1997, now U.S. Patent 5,843,314, which is a continuation of application serial No. 08/542,730, filed October 13, 1995, now U.S. Patent 5,696,801, which claims the benefit of provisional application Serial No. 60/003,266, filed August 24, 1995.

20        **BACKGROUND OF THE INVENTION**

      The present invention relates generally to the field of strainer systems, and more particularly to the field of flow control strainer systems employed for filtering and controlling the in-flow and discharge of water for industrial plants such as power plants.

25        Strainer systems such as suction strainers are generally employed in a variety of different applications for filtering solids and particulate matter from a flow of fluid being drawn into or exhausted from a fluid flow line. For example, suction strainers are often used in suppression pools to remove solids from a flow of liquid (e.g., water) being drawn into an emergency core cooling system  
30    (ECCS) or suction pump for a power plant. The flow of water is drawn through the suction strainer and then into the suction line of the ECCS pump.

Employment of suction strainers is desirable because solid debris drawn into the suction line of a pump can degrade pump performance by accumulating in the pump or its suction or discharge lines, or by impinging upon and damaging internal pump components.

5           While almost any pump degradation can be characterized as being costly, the degradation of ECCS pump performance at, for example, Boiling Water Reactor ("BWR") nuclear power plants can be detrimental to safe plant shutdown following a loss of coolant accident (LOCA). At a BWR nuclear power plant following a LOCA, it is critical for the ECCS pumps to operate for an extended  
10   period of time in an undegraded fashion. In one mode of operation, the ECCS pumps are operated to recirculate water from the suppression pool back to the reactor core for the purpose of core cooling. A LOCA results from a high pressure pipe rupturing with such great force that large quantities of debris, such as pipe and vessel insulating material, and other solids, may be washed into the  
15   suppression pool. Conventional ECCS suction strainers currently installed in BWR plants have a tendency to become clogged by such debris due to their small size and design. Also, when the large pressure pipes rupture with great force, suction strainers in the suppression pool are subjected to great hydrodynamic forces that can damage the suction strainers as well as subject the attachment  
20   recirculation piping to large reactive forces. These structural considerations, and space constraints, limit the size and shape of conventional suction strainers in suppression pools.

          Conventional suction strainers are typically constructed and arranged in a manner such that, under full flow conditions, localized high entrance velocities  
25   are established through that portion of the suction strainer that is most proximate to the suction line of the pump, while low entrance velocities are established through that port of the suction strainer that is more distant from the suction line of the pump. The high entrance velocities may draw more solid debris into contact with the suction strainer causing the portions of the suction strainer  
30   experiencing the high entrance velocities to experience higher head loss. As the

portion of the suction strainer most proximate to the suction line collects debris, high entrance velocities are established at the portion of the suction strainer that is next closest to the suction line causing that portion to collect debris. This process often continues until the entire suction strainer has collected debris in varying quantities, resulting in a non-uniform build-up of debris on the outer surface of the strainer.

Localized high entrance velocities can be detrimental even when solids are not present in the liquid being pumped. For example, high entrance velocities can result in turbulent flow which tends to create greater pressure losses than laminar flow. Any such pressure losses reduce the net positive suction head (NPSH) available to a pump. As the NPSH available decreases, pump cavitation may occur. Similarly, localized high entrance velocities can cause vortexing. When a suction strainer is not sufficiently submerged, such vortexing can cause air ingestion that can severely degrade pump performance.

Attempts have been made to resolve certain of the problems associated with suction strainer-like devices in other applications. For example, cylindrical suction flow control pipes have been encircled with screen material and employed in water wells. Such wells typically employ a well pump above the ground surface and a riser pipe extending from the well pump to the water table. The suction flow control pipe is connected to the end of the riser pipe and extends further below the water table. Openings are defined through the side wall of the suction flow control pipe such that there is somewhat less open area near the riser pipe and somewhat more open area distant from the riser pipe. As a result, when water is drawn into the flow control pipe through the openings, a substantially uniform inflow distribution is defined along the length of the flow control pipe. While such suction flow control pipes offer some advantages, they are not suitable for all applications.

Attempts also have been made, separate from flow control pipes, to increase filtering surface areas of suction strainers in uses such as at power plants in an effort to decrease pressure losses and thereby prevent pump cavitation. For

example, such suction strainers may include a plurality of spaced, coaxial, stacked filtering disks. More particularly, such stacked disk suction strainers typically include an annular flange for attachment to the corresponding flange on the pump suction line.

5           The stacked disk suction strainer provides an enhanced surface area and defines a longitudinal axis that is encircled by the attachment flange. A first disk is attached to the attachment flange. The first disk includes a pair of radially extending, circular, disk walls, each of which encircle the longitudinal axis, and define a central hole. A first disk wall of the pair of disk walls is connected to the  
10 attachment flange. The first and second disk walls of the pair of disk walls are connected to the attachment flange. The first and second disk walls of the pair of disk walls face one another and are separated by a slight longitudinal distance. The first disk further includes an outer annular wall that encircles the longitudinal axis. The outer annular wall includes an annular first edge and an annular second  
15 edge. The entirety of the annular first edge of the outer annular wall is connected to the entire peripheral edge of the first perforated disk wall; and the entirety of the annular second edge of the outer annular wall is connected to the entire peripheral edge of the second perforated disk wall such that the pair of disk walls are connected at their periphery.

20           The stacked disk suction strainer further includes a plurality of inner annular walls that encircle the longitudinal axis, each of which includes an annular first edge and an annular second edge. The annular first edge of one of the inner annular walls is connected around the periphery of the central hole of the second disk wall. The annular second edge of that inner annular wall is connected  
25 around the periphery of the central hole of a disk wall of a second disk. The first and second disk walls and the outer and inner annular walls are perforated and comprise the filtering surface of the stacked disk suction strainer. Additional perforated disks and inner annular walls are attached to one another in the above manner until the last disk is attached, wherein the outer disk wall of the last disk  
30 does not include a central hole. The stacked disk suction strainers may

incorporate separate structural members to maintain the structural integrity of the stacked disk suction strainer. However, the conventional stacked disk suction strainers do not incorporate an internal core tube and related components, whereby the conventional stacked disk suction strainers are difficult to  
5 structurally reinforce and are susceptible to vortexing and the detrimental non-uniform localized entrance velocities discussed above.

In addition, in other applications such as for steam electric generating stations that operate by the generation of steamed power turbines, and thus require service water for steam condensation or other types of plant cooling to be drawn  
10 from a local lake, river, bay, ocean or cooling pond, it is critical for debris and foreign objects, such as leaves, grass, branches, dead fish, etc. as well as other small aquatic swimming life to be filtered out of this intake water to the fullest extent possible. Typically, for such steam electric generating stations, the cooling water is pumped through immovable trash racks and then typically through a  
15 travelling screen to filter the water, which is then pumped into heat exchangers located inside the plant to provide cooling. The travelling screens generally screen out materials with dimensions larger than one inch to two inches and are driven in a recirculating path by an electric motor or similar drive. In addition, further filtering materials or systems often are positioned downstream from the  
20 travelling screens to further screen out materials down to 1/8 of an inch.

Such travelling screens and stationary trash racks, however, frequently must be cleaned as the water velocity approaching both the trash racks and travelling screens typically is being drawn in at approximately 2 to 2 1/2 feet per second. Such a relatively large approach velocity tends to cause small fish,  
25 turtles, frogs and other live aquatic animal life to be drawn through the trash racks and onto the travelling screens, causing the death of such aquatic life. Thus, such traveling screens typically require frequent cleaning and pose environmental risks. New state environmental laws designed to protect such animal life also are now threatening to make these high velocity travelling screens obsolete.

In addition, such trash racks and traveling screens generally have proved ineffective for screening out larvae and other forms of non-swimming aquatic animal life such as certain species of mussels, clams and bryozoa. These larvae tend to pass through the travelling screen and other filters and often collect on the insides of heat exchanger tubes and subsequently grow into adults, blocking the heat exchanger tubes and thus impeding the flow of cooling water through the heat exchanger tubes. Currently, such larvae are attempted to be controlled through the use of chemical treatments which are, however, very expensive and increase heat exchanger corrosion, and are not usually 100% successful. Further, once the larvae have grown into adult mussels, clams, etc., most such adult animals typically are nearly impossible to kill by chemical treatment and thus these adult animals must be physically cleaned from the insides of the heat exchanger tubes, requiring a shutdown of the facility which is expensive and time consuming.

The large approach velocities of conventional inflow or intake systems for which the trash racks and travelling screens currently are used also require sufficient size flow openings to avoid pressure drops therealong. As a result of such high approach velocities, it generally is impractical to use finer mesh screening materials for filtering out such larvae and other small aquatic animal life as such fine mesh screens tend to become clogged very rapidly, requiring frequent cleaning and replacement.

There is, therefore, a need in the industry for an improved suction strainer system.

## SUMMARY OF THE INVENTION

Briefly described, the preferred embodiments of the present invention include a strainer system for filtering a fluid flow while controlling the flow therethrough to reduce flow velocities and enable more uniform distribution of the flow along the strainer system. The strainer system includes a filtering device with a strategically enlarged filtering surface and an internal core. The internal



core is preferably in the form of an internal core tube, which is preferably an internal pipe with flow openings. In accordance with the preferred embodiments of the present invention, the internal core tube structurally reinforces the filtering device.

5           In accordance with the preferred embodiments of the present invention, the internal core tube has a downstream end for connection to the pump suction flange and an upstream end distant from the downstream end. The internal core tube defines a longitudinal axis extending between the upstream and downstream ends. In accordance with the preferred embodiments of the present invention, a  
10   plurality of openings are defined through the side wall of the internal core tube. In accordance with certain examples of the preferred embodiments, the openings are constructed and arranged such that the openings vary in size along the length of the core tube so that there is somewhat less open area near the downstream end than the upstream end of the core tube, and the amount of open area tapers  
15   between the upstream end and the downstream end of the core tube. As a result, when water flows into the internal core tube through the openings, a substantially uniform flow rate distribution is defined along substantially the entire length of the internal core tube.

          In a first embodiment of the present invention comprising a suction  
20   strainer in which the structural reinforcement provided by the internal core tube is enhanced by reinforcing structural members that extend radially from the internal core tube. The reinforcing structural members are preferably connected to and extend radially from and angularly around the internal core tube to structurally support the filtering surfaces of the external filtering structure. The internal core  
25   tube, in conjunction with the structural members, seeks to prevent air ingestion and vortexing. The suction strainer preferably extends away from the suction line of an ECCS pump to define a length, and in accordance with certain examples of the preferred embodiments of the present invention, the internal core tube seeks to promote controlled inflow along the length to preclude the establishment of non-  
30   uniform localized entrance velocities through the filtering surface. In accordance

with other examples of the preferred embodiments of the present invention, the internal core tube is not constructed to specifically promote such a uniform inflow along the length.

In accordance with the first embodiment of the present invention, the  
5 suction strainer is constructed in a manner that seeks to enlarge the filtering surface while minimizing the projected area of the suction strainer. The minimization of the projected area as well as structural reinforcement of the suction strainer enables the suction strainer to withstand high levels of hydrodynamic impact loading following a LOCA. The suction strainer also  
10 serves to minimize the bending moment and other reactive forces on the attachment ECCS piping in the BWR suppression pool.

The filtering surface is defined by an external filtering structure that is attached to, extends from, and is built around the internal core tube and the reinforcing structural members. When the suction strainer is connected to the  
15 suction of a pump and submerged, a liquid flow path is established through the internal core tube and external filtering structure. The liquid originates exterior to the external filtering structure and is drawn through the filtering surfaces of the external filtering structure. The filtering surfaces separate solids from the liquid. The size of the filtering surface is enlarged by virtue of the fact that the filtering  
20 surface defines protrusions such that the distance that the filtering surface extends from the internal core tube alternates. The resulting enlarged filtering surface seeks to decrease average flow velocities through the filtering surface and thereby spread the collected solid debris in thinner layers, thereby decreasing overall pressure losses associated with the suction strainer. Once the liquid flows through  
25 the filtering surface, the liquid is drawn through the internal core tube and into the suction of the pump.

The protrusions of the external filtering structure are in the form of a plurality of filtering plate assemblies that are connected to and extend radially from the internal core tube. Each plate assembly includes a pair of plate walls  
30 that face one another, define a distance therebetween, and are connected at their

peripheries by an outer wall that surrounds that internal core tube. A separation distance is defined between neighboring plate assemblies. Inner walls connect between neighboring plate assemblies and extend around the internal core tube at a radius less than the radius of the outer walls. The outer and inner walls as well as the plate walls are perforated and comprise the filtering surfaces of the suction strainer. In accordance with first and second embodiments of the present invention, the plurality of plate assemblies are preferably in the form of stacked disks that are spaced to define troughs therebetween. In accordance with other embodiments, the plate assemblies are in other forms that increase the surface area of the suction strainer.

In an additional embodiment of the present invention for use in other types of applications such as for use in a service water intake to filter intake water being drawn in from lakes, rivers, oceans, collection ponds, etc. to remove solids and small aquatic life. The suction strainers are designed to provide reduced, low approach velocities that are uniform along the strainers length to reduce the threat of harm to such aquatic life. In such an embodiment, the strainer includes an internal core tube having an upstream end that typically is connected to a suction or intake pipe, a closed downstream end, and a substantially cylindrical core wall defining an internal chamber. Core openings or slots of varying sizes are formed through the core wall at spaced positions between the upstream and downstream ends of the core tube.

Typically, the core openings will gradually increase in diameter along the length of the core tube from the downstream toward the upstream end of the core tube. The varying size openings or slots formed through the core tube help to reduce the approach velocity while providing a substantially uniform flow and approach velocity along the length of the core tube. An external screening structure is mounted over the core tube, typically spaced approximately 3 to 6 inches from the core wall. The external screening structure generally is formed from sections of a fine mesh filtering material having mesh openings of a sufficient size to enable small non-swimming aquatic life such as various types of

larvae to be substantially filtered from intake water passing therethrough, overlaid with at least one exterior strainer shell or screen.

The exterior screening structure generally is mounted in sections fitting about the core tube, being supported on a support frame which supports the screen in a spaced configuration from the core tube. The low uniform approach  
5 velocities provided by the core tube as intake water is drawn therein helps reduce the instances of fish and other aquatic life being pulled into and caught on the mesh filtering material. The suction system of this embodiment thus enables small, non-swimming aquatic life such as larvae of mussels, clams, etc., to be  
10 caught and filtered from the intake water flow by the exterior screening structure without unduly clogging the fine mesh filtering material so as to require frequent cleaning or replacement thereof.

In a further, alternative embodiment of the present invention, the suction strainer further can be used as a discharge filtering mechanism for filtering solids, rust, dirt and other particulate matter from discharge fluids. In such a use, the  
15 suction strainer includes the internal core tube having upstream and downstream ends, a core wall and varying size openings formed through the core wall, with the diameter size of the core openings increasing between the upstream and downstream ends of the core tube. A removable pipe jacket is positioned over the  
20 core tube. The pipe jacket generally comprises a filtering or insulation material such as a fiberglass type insulation material for filtering out rust, dirt and other particulate matter and debris from the discharge water flow. A porous, expanded metal retaining jacket further is mounted about the core tube and filter jacket, generally being secured with locking clasps or similar releasable locking  
25 mechanisms. The metal retaining jacket helps hold the filter jacket in place about the core tube and protects the filter jacket while allowing the discharge water to readily flow therethrough.

It is therefore an object of the present invention to provide an improved strainer system for fluid flows.

Another object of the present invention is to increase safety by improving the operability of the ECCS of a BWR nuclear plant following a LOCA.

Yet another object of the present invention is to structurally reinforce a suction strainer sufficiently so that it can withstand the hydrodynamic forces  
5 following a LOCA in the suppression pool at a BWR nuclear plant.

Still another object of the present invention is to minimize reactive forces on the attachment ECCS piping following a LOCA.

Still another object of the present invention is to maximize the total strainer surface area within a limited geometric profile while providing a  
10 maximum strength strainer.

Still another object of the present invention is to simultaneously minimize both the thickness of collected debris on the strainer and the average entrance or approach velocities.

Still another object of the present invention is to maximize the amount of  
15 time required to reach a particular head loss across the strainer.

Still another object of the present invention is to control the distribution of fluid flow over the strainer so as to collect debris uniformly to allow scaling of the strainer for other flow rates with similar, but different size, strainers with different water flow rates.

Still another object of the present invention is to prevent vortexing and air  
20 ingestion.

Still another object of the present invention is to reduce approach velocities for water drawn into a service water intake to achieve greater uniformity of flow and enable finer filtering of the intake water flow to remove larvae and  
25 small particulate matter therefrom.

A further object of the present invention is to control and reduce the flow velocities for a discharge flow while enabling filtering of particulate matter therefrom.

Other objects, features and advantages of the present invention will become apparent upon reading and understanding this specification, taken in conjunction with the accompanying drawings.

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### **BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1 is a schematic, downstream end, perspective view of a suction strainer with an internal core tube in accordance with one example of the first preferred embodiment of the present invention.

10 Fig. 2 is a schematic, partially cut-away, upstream end, perspective view of the suction strainer of Fig. 1.

Fig. 3 is a schematic, side elevational view of a suction strainer with an internal core tube in accordance with one example of the second preferred embodiment of the present invention.

15 Fig. 4 is a schematic, upstream end, elevational view of the suction strainer of Fig. 3.

Fig. 5 is an isolated, plan view of an internal core tube of the suction strainer of Fig. 3, wherein the internal core tube is in an unrolled and flattened configuration.

20 Fig. 6 is an isolated, schematic, elevational view of a wall of a filtering portion of the suction strainer of Fig. 3.

Fig. 7 is an isolated, plan view of a structural member of the filtering portion of the suction strainer of Fig. 3.

25 Fig. 8 is an isolated, schematic, plan view of an outer wall of the filtering portion of the suction strainer of Fig. 3, wherein the outer wall is in an unrolled and flattened configuration.

Fig. 9 is an isolated, schematic, plan view of an inner wall of the filtering portion of the suction strainer of Fig. 3, wherein the inner wall is in an unrolled and flattened configuration.

Fig. 10 is a schematic representation of portions of a BWR nuclear power plant, wherein the suction strainer of Fig. 1 is connected to the ECCS of the power plant.

Fig. 11 is a schematic, side elevational view of a suction strainer with an internal core tube in accordance with an alternate embodiment of the present invention.

Fig. 12 is a schematic, upstream end, elevational view of a suction strainer with an internal core tube in accordance with another alternate embodiment of the present invention.

Fig. 13 is a schematic, side elevational view of the suction strainer of Fig. 12.

Fig. 14 is a side elevational view of an additional embodiment of the core tube for use in water intake straining and discharge straining operations.

Fig. 15 is a perspective view of an additional embodiment of the suction strainer for use in filtering intake water.

Fig. 16 is an end view taken in partial cross section along lines A-A of Fig. 15 of the embodiment of the suction strainer shown in Fig. 15.

Fig. 17 is a side elevational view of one of the panels of the exterior screening structure as indicated at "B" in Fig. 16.

Fig. 18 is an end view taken in cross section of a portion "B" of the exterior screening structure shown in Fig. 16.

Fig. 19A is a side elevational view of the suction strainer of Fig. 15 shown in a first alternative arrangement for filtering intake water.

Fig. 19B is a plan view of the suction strainer system illustrated in Fig. 19A.

Fig. 20A is a side elevational view of an additional operative arrangement for a suction strainer system using the suction strainer of Fig. 15 in a vertical orientation.

Fig. 20B is a plan view of the suction strainer system of Fig. 18A.

Fig. 21 is a side elevational view of a further embodiment of the suction strainer of the present invention.

Fig. 22 is an end view taken in partial cross section of the embodiment of the suction strainer illustrated in Fig. 21.

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#### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

Referring now in greater detail to the drawings, in which like numerals represent like components throughout the several views, various embodiments of a suction strainer system for filtering solids and particulate matter from fluid  
10 flows. The suction strainer system can be adapted for use in filtering fluid flows in a variety of industrial applications, including use in a suction line for a pump, for water intake lines for filtering solids and small aquatic life from a service water intake flow, as well as for filtering fluids along a discharge line.

Fig. 1 illustrates a schematic, perspective view of a suction strainer 20  
15 with a core, in accordance with a first example of a first preferred embodiment of the present invention. The core is in the form of an internal core tube 26, and the suction strainer 20 further includes an upstream end 22, an opposite downstream end 24, and an exterior filtering structure 28 connected to and at least partially bounding the internal core tube 26. The internal core tube 26 is preferably in the  
20 form of a cylinder that structurally reinforces exterior filtering structure 28. The internal core tube 26 extends between the ends 22, 24, and protrudes from the filtering structure 28 at the downstream end 24. The internal core tube 26 includes a core wall 30 that encircles and defines a core chamber 32. The core wall further defines a primary opening 33 that provides access to the core  
25 chamber 32, and the longitudinal axis 34 of the suction strainer 20. The portion of the core wall 30 that is internal to the filtering structure 28 preferably defines a plurality of openings therethrough (for example, see openings 74, 76, 78 defined through core wall 30' in Fig. 5), as will be discussed in greater detail below. The portion of the core wall 30 that extends from the filtering structure 28 at the  
30 downstream end 24 generally is preferably not perforated.



The filtering structure 28 encircles a majority of the internal core tube 26 and includes an exterior filtering surface 40. As will be discussed in greater detail below, the entire filtering surface 40 is preferably perforated (i.e., the filtering surface 40 defines a plurality of openings therethrough), although the perforations are not depicted in Fig. 1 in an effort to clarify the view. The filtering surface 40 further defines a plurality of protrusions such that the contour of the filtering surface 40 is varied to uniquely maximize the effective filtering area of the filtering surface 40 within a limited geometric profiles described by the length and outer diameter of the suction strainer 20. The filtering structure 28 includes a plurality of spaced protrusions which cooperate to define peaks and valleys:

In accordance with a first embodiment of the present invention, the protrusions are in the form of plate assemblies 42a-c which are preferably in the form of circular disks, and the valleys defined between the disks are in the form of annular troughs. The disks and troughs are preferably arranged in a uniform and consistent pattern. While the suction strainer 20 is constructed in a manner that seeks to maximize its filtering surfaces 40, that construction also seeks to reduce the projected area of the suction strainer 20 such that the suction strainer 20 can withstand both high levels of hydrodynamic impact loading and minimize bending moments on the attachment piping 102 (Fig. 10).

An annular connection flange 38 encircles and is connected to the core wall 30 at the downstream end 24. The connection flange 38 is preferably constructed and arranged for attachment to a corresponding flange (not shown) in the suction line 102 (Fig. 10) of a pump 104 (Fig. 10). The connection flange 38 is depicted in a simplified form in Fig. 1 in an effort to clarify the view. The connection flange 38 preferably includes a plurality of bolt holes (not shown) therethrough that facilitate connection to the corresponding flange, as should be understood by those reasonably skilled in the art. In accordance with the preferred embodiments of the present invention, the connecting flange 38 refers, for example and not limitation, to a standard bolted flange connection. In accordance with alternate embodiments of the present invention a flange 38 is not

employed, and the suction strainer 20 is connected to the suction line 102 by virtue of threading, welding, or other conventional fastening techniques or devices.

When the suction strainer 20 is connected to the suction line 102 (Fig. 10) of a pump 104 (Fig. 10), such as, for example, and ECCS pump, liquid is drawn into the suction strainer 20 through the perforations defined through the filtering surface 40. The filtering surface 40 functions to collect solids (not shown) on the suction strainer 20. Once liquid is drawn through the filtering surface 40, the liquid is drawn through the openings (for example, see openings 74, 76, 78 in Fig. 5) defined through that portion of the core wall 30 that is internal to the filtering structure 28.

Referring back to the plate assemblies 42a-c, they preferably encircle the longitudinal axis 34, and the exposed surfaces of the plate assemblies 42a-c constitute a substantial portion of the filtering surface 40. The plate assemblies 42a-c include perforated plate walls 44a-f and perforated outer annular walls 46a-c that preferably encircle the longitudinal axis 34. More particularly, and representative of the construction of the plate assemblies 42b, c, the plate assembly 42a includes the plate walls 44a, b which face one another and are separated by a longitudinal distance. The plate walls 44a, b each define a peripheral edge (as an example, see peripheral edge 47 of plate wall 44' in Fig. 6), and the outer wall 46a spans and is connected between the peripheral edge of the plate wall 44a and the peripheral edge of the plate wall 44b. Each of the plate walls 44a-e define a plate hole (as an example, see plate hole 48 of plate wall 44' in Fig. 6) therethrough, and the plate holes are preferably circular and centered with respect to their respective plate wall 44a-e. The internal core tube 26 extends and is connected through the plate holes (as an example, see plate hole 48 of plate wall 44' in Fig. 6). The filtering structure 28 further includes a plurality of inner walls 43a, b. The inner walls 43a, b are preferably annular. The inner walls 43a, b are also preferably perforated such that they constitute the remainder of the filtering surface 40. The inner walls 43 a, b preferably encircle the

longitudinal axis 34, and the inner wall 43a is connected between the plate assemblies 42a, b while the inner wall 43b is connected between the plate assemblies 42b, c.

Fig. 2 is a schematic, partially cut-away, upstream end, perspective view of the suction strainer 20, in accordance with the first embodiment of the present invention. Portions of the plate assemblies 42b, c and the inner wall 43b are cut-away to expose the portion of the internal core tube 26 that is proximate to the upstream end 22. Fig. 2 is schematic in nature by virtue of the fact that perforations are not shown extending through the plate assemblies 42a-c or the inner walls 43a, b, and the openings (for example, see openings 74, 76, 78 in Fig. 5) that extend through the core wall 30 are not depicted in an effort to clarify the view. As mentioned above, the plate walls 44a-e each define a plate hole (for example see plate hole 48 in Fig. 6) therethrough, through which the internal core tube 26 extends and is connected. Conversely, the plate wall 44f, which is partially cut-away in Fig. 2, does not define such a plate hole such that the plate wall 44f functions to cover the upstream end 22 of the internal core tube 26 and the core chamber 32. Except for that difference between the plate wall 44f and the other plate walls 44a-e, the plate assembly 42c is representative of the plate assemblies 42a, b.

In accordance with the first embodiment of the present invention, the internal core tube 26 functions as a structural member that supports the filtering structure 28. The filtering structure 28 and the internal core tube 26 are interconnected in a manner that synergistically strengthens the suction strainer 20. This strengthening is enhanced by a plurality of structural members 50 that are preferably rectangular and planar. The structural members 50 are disposed within and are effectively part of each of the plate assemblies 42a-c. Some of the structural members 50 are cut-away in Fig. 2 to clarify the view. In addition, a plurality of shorter, preferably rectangular and planar, structural members 52 are associated with each of the inner walls 43a, b. In accordance with the first embodiment of the present invention, the structural members 50, 52 are solid. In

accordance with alternate embodiments of the present invention, holes or other perforations are defined through the structural members 50, 52. The solid structural members 50, 52 function to both structurally reinforce the filtering structure 28 and prevent vortexing and air ingestion.

5           More particularly, and representative of the construction of the plate assemblies 42 a, b, the structural members of plate assembly 42c extend radially from the core wall 30 and are angularly displaced about the longitudinal axis 34. Each of the structural members 50 includes an inner edge (for example, see inner edge 54 of structural member 50' in Fig. 7) connected to the core wall 30, an  
10   opposite outer edge (for example, see outer edge 56 in Fig. 7) connected to the outer annular wall 46c, a side edge (for example, see side edge 58 in Fig. 7) connected to the plate wall 44f, and an opposite side edge (for example, see side edge in Fig. 7) connected to the plate wall 44e. Further, and representative of the plate assemblies 42a, b, the plate assembly 42c defines an annular plate chamber  
15   62 that is bound by the core wall 30, the outer annular wall 46c, the plate wall 44f, and the plate wall 44e.

          The inner wall 43b is representative of the inner wall 43a. The inner wall 43b is connected to a plurality of the structural members 52, wherein the structural members 52 extend radially from the core wall 30 and are angularly  
20   displaced about the longitudinal axis 34. Each of the structural members 52 is similar to but sized differently from the structural members 50. Each of the structural members 52 associated with the inner wall 43b include an inner edge connected to the core wall 30, an opposite outer edge connected to the inner wall 43b, a side edge connected to the plate wall 44e, and an opposite side edge  
25   connected to the plate wall 44d. (For example, see the inner edge 54, outer edge 56, side edge 58, and side edge 60 of the structural member 50' in Fig. 7). Further, the inner wall 43b defines an intermediate chamber 64 that is bounded by the core wall 30, the inner wall 43b, inner portions of the plate wall 44e, and inner portions of the plate wall 44d. Each of the plate assemblies 42a-c define plate  
30   chambers 62 and each of the inner walls 43a, b define intermediate chambers 64,

and all of the chambers 62, 64 comprise a filter chamber 66. Stated differently, the filter chamber 66 is defined between the core wall 30 and the filtering surface 40 of the filtering structure 28.

As discussed in greater detail below with reference to a first example of a second preferred embodiment of the present invention, the openings defined through the core wall 30 (for example see openings 74, 76, 78 defined through core wall 30' in Fig. 5) are constructed and arranged so that a substantially controlled inflow distribution, which is preferably uniform, is defined along the length of the internal core tube 26 that is internal to the filtering structure 28. A uniform inflow distribution seeks to, among other things, collect the debris on the filtering surface 40 uniformly, from disk to disk or trough to trough, and thereby allow scaling of test results to strainers with different flow rates and different surface areas. This flow pattern control also seeks to assist in preventing vortexing and air ingestion at the suction strainer 20. In accordance with other examples of the first embodiment, the openings defined through the core wall 30 are constructed and arranged so that the internal core tube 26 does not seek to control the inflow distribution.

Fig. 3 is a schematic, side elevational view of a suction strainer 20' in accordance with a second preferred embodiment of the present invention. The suction strainer 20' of the second embodiment is very similar, in general terms, to the suction strainer 20 (Figs. 1 and 2) of the first example of the first embodiment. Thus, except where specific differences between the suction strainer 20' and the suction strainer 20 are noted or apparent, the following disclosure of the suction strainer 20' should be considered as a supplement to the foregoing disclosure of the suction strainer 20, and visa versa.

In accordance with the second embodiment of the present invention, the internal core tube 26' of the suction strainer 20' is preferably cylindrical and longer than the internal core tube 26 (Figs. 1 and 2) of the first embodiment. Further, the suction strainer 20' includes more inner walls 43'a-e and plate assemblies 42'a-f than the suction strainer 20 (Figs. 1 and 2) of the first

embodiment. The plate assemblies 42'a-f include plate walls 44'a-l. The inner walls 43'a-e and plate assemblies 42'a-f preferably encircle the internal core tube 26', as is indicated by the broken line showing of the internal core tube 26'. Fig. 3 is schematic in nature because, while the inner walls 43'a-e and plate assemblies 42'a-f preferably define a multiplicity of apertures therethrough, those apertures are not depicted in Fig. 3 in an effort to clarify the view. The internal core tube 26' is preferably in the general form of a cylinder that structurally reinforces exterior filtering structure 28'.

In accordance with the second embodiment of the present invention, the suction strainer 20' defines an overall length that is represented by the dimension "a". The core wall 30' defines a first length that does not define openings 74, 76, 78 (Fig. 5) therethrough, and that first length is represented by the dimension "b". The core wall 30' further defines a second length, represented by the dimension "c", that does define openings 74, 76, 78 (Fig. 5) therethrough and that is surrounded by the plate assemblies 42'a-f and the inner walls 43'a-e. A separation distance, represented by the dimension "d", is defined between each of the plate assemblies 42'a-f. Also, each of the plate assemblies 42'a-f individually define a thickness that is represented by the dimension "e". The internal core tube 26', inner walls 43'a-e, and plate assemblies 42'a-f define diameters that are represented by the dimensions "f", "g", and "h", respectively. In accordance with one example of the second embodiment, and in approximation, the dimension "a" is acceptably 36.0 inches, the dimension "b" is acceptably 3.375 inches, the dimension "c" is acceptably 29.875 inches, the dimension "d" is acceptably 2.0 inches, the dimension "e" is acceptably 3.313 inches, the dimension "f" is acceptably 24.0 inches, the dimension "g" is acceptably 26.0 inches, and the dimension "h" is acceptably 42.0 inches.

As suggested by the broken line showing of the core wall 30' in Fig. 3, each of the plate walls 44'a-k defines a centered plate hole 48 (Fig. 6) therethrough. The internal core tube 26' extends through the plate holes 48. As an exception, however, the plate wall 44'l does not define such a hole 48 and

therefore covers the upstream end 22' of the internal core tube 26' and the core chamber (for example see the core chamber 32 of Figs. 1 and 2). The plate wall 44'l is more fully depicted in Fig. 4, which is a schematic, upstream end elevational view of the suction strainer 20'. The fact that the plate wall 44'l covers the upstream end 22' of the internal core tube 26' is indicated by the broken line showing the core wall 3' in Fig. 4.

In accordance with the second preferred embodiment of the present invention, each of the plate assemblies 42'a-f (Fig. 3) include a plurality of structural members 50' therein; and the arrangement and configuration of the structural members 50' within the plate assembly 42'f is representative of the configuration and arrangement of the structural members 50' within each of the plate assemblies 42'aa-e. As indicated by the broken line showing of the structural members 50' in Fig. 4, the structural members 50' extend radially from and are angularly displaced about the internal core tube 26'. An identical angle "φ" is defined between each adjacent structural member 50', and one acceptable example of the angle "φ" is 60 degrees. In accordance with the second embodiment of the present invention, the inner walls 43'a-e are not reinforced by structural components that correspond to the structural members 52 (Fig. 2) of the first preferred embodiment. However, in accordance with alternate embodiments of the present invention the inner walls 42'a-e are reinforced by structural components that correspond to the structural members 52 (Fig. 2) of the first preferred embodiment.

Fig. 5 is an isolated, plan view of the core wall 30' in accordance with a first example of the second embodiment of the present invention, wherein the core wall 30' is in an unrolled and flattened configuration. The core wall 30' includes opposite wall edges 68, 70 that are preferably joined together in a manner that creates the cylindrical internal core tube 26' (Fig. 3). The internal core tube 26' further includes an upstream edge 71 to which the plate wall 44'l (Figs. 3 and 4) is affixed. Broken lines 72a-k are included in Fig. 5 for explanatory purposes only. The lines 72a-k represent the points at which the inner peripheral edges 73

(Fig. 6) of the plate walls 44a-k (Fig. 3), respectively, contact the core wall 30' when the plate walls 44a-k are properly installed on the cylindrical internal core tube 26' (Fig. 3).

The openings 74, 76, 78, only a few of which are specifically pointed out in Fig. 5 in an effort to clarify the view, are in the form of circular holes which extend through the core wall 30'. Also, in accordance with the second preferred embodiment of the present invention, open areas are defined through the core wall 30' by virtue of the openings 74, 76, 78. Each individual opening 74, 76, 78 represents or defines an open area. The open area of an individual opening 74, 76, 78 is representative of the capacity of that individual opening 74, 76, 78 to pass liquid. Thus, the open area can acceptably be measured perpendicular to the direction of liquid flow through the most restrictive portion of an opening 74, 76, 78. In accordance with the first example of the second embodiment of the present invention, the openings 78 are defined between the lines 72d, h, and the upstream end 22' of the core wall 30', the openings 76 are defined between the lines 72d, h, and the openings 74 are the only type of openings defined between the lines 72a, d.

Unit areas consisting of a portion of the core wall 30' can be considered to define open areas, wherein the open area of a unit area is the summation of all of the individual open areas defined within that unit area. Accordingly, for example and not limitation, a plurality of core units can be defined as extending sequentially along the length of the internal core tube 26' (Fig. 3). A first unit of the plurality of units can acceptably and hypothetically be identified as being that portion of the core wall 30' defined between the lines 72b, d. That first unit defines a first unit open area equal to the summation of the open areas of each of the openings 74 defined between the lines 72b, d. Similarly, a second unit of the plurality of units can acceptably and hypothetically be identified as being that portion of the core wall 30' defined between the lines 72d, f. That second unit defines a second unit open area equal to the summation of the open areas of each of the openings 76 defined between the lines 72d, f.



Accordingly, the first unit open area is smaller than the second unit open area such that when a pump draws liquid through the wall 30' of the internal core tube 26' (Fig. 3), the flow (i.e., inflow) of liquid through the first unit is substantially similar to the inflow of liquid through the second unit. The lines 72a-k are used in the foregoing example only because they aid in the explanation of the concept of core units. The lines 72a-k are not intended to and should not limit the hypothetical configuration of core units. Core units can be conceptualized and defined without any reference to the lines 72a-k. For example and not limitation, it is acceptable for the edge of a core unit to be located at any location between neighboring lines 72.

As evidenced by the foregoing, the openings 74, 76, 78 are constructed and arranged such that less open area is defined near the downstream end 24' (Fig. 3) than the upstream end 22' (Fig. 3). Thus, when liquid is drawn into the core chamber (for example see the core chamber 32 of Figs. 1 and 2) by a pump or the like, a substantially uniform flow (i.e., inflow) distribution is defined along the length of the internal core tube 26' (Fig. 3). Variation in open area of the core wall 30' (e.g., the variation in the open area of the internal core tube 26') is achieved by varying the sizing of the openings 74, 76, 78. In other words, in accordance with the first example of the second preferred embodiment of the present invention, the pattern of the openings 74, 76, 78 does not vary significantly along the length of the core wall 30'. More particularly, the opening pattern defined between the lines 72a, b is repeated between the lines 72c, d, the lines 72e, f, the lines 72g, h, the lines 72i, j, and the line 72k and the upstream end 22' of the core wall 30'.

Similarly, the opening pattern defined between the lines 72b, c is repeated between the lines 72d, e, the lines 72f, g, the lines 72h, i, and the lines 72j, k. Variation in open area then is achieved by virtue of the fact that the openings 78 generally are larger than the openings 74; and the openings 74 generally are larger than the openings 72 (which are preferably the only type of openings defined between the lines 72a, d). Each of the openings 74 acceptably defines a diameter

of approximately 0.875 inches, each of the openings 76 defines a diameter of approximately 1.063 inches, and each of the openings 78 defines a diameter of approximately 1.25 inches. Also, the core wall 30' is acceptably constructed from a sheet of steel such as, but not limited to, a piece of quarter inch coated A36 carbon or uncoated stainless steel.

In accordance with the first example of the second embodiment of the present invention, the variations in open area along the length of the internal core tube 26' (Figs. 3 and 4) are established by repeating the pattern of openings but varying the size of the openings defined through the core wall 30'. However, in accordance with alternate embodiments of the present invention all of the openings defined through the core wall 30' are the same size, and the variations in open area along the length of the internal core tube 26' (Fig. 3) are established by varying the pattern of the openings through the core wall 30'. In other words, in alternate embodiments of the present invention, the variation in open area exists by virtue of the fact that more openings are defined through the core wall 30' proximal to the upstream end 22' (Fig. 3) of the internal core tube 26'. Also, in accordance with other examples of the second embodiment, the open areas through the core wall 30' are substantially uniform along the length of the internal core tube 26', whereby uniform inflow along the length of the internal core tube 26' is not provided.

Fig. 6 is an isolated, schematic, elevational view of a plate wall 44' that is representative of the plate walls 44'a-k (Fig. 3), in accordance with the second preferred embodiment of the present invention. The plate wall 44' includes an outer peripheral edge 47 and an inner peripheral edge 73 that encircles and defines a central plate hole 48. The internal core tube 26' (Fig. 3) extends through the central plate holes 28 of the plate walls 44'a-k (Fig. 3). The plate wall 44' depicted in Fig. 6 is not representative of the plate wall 441 (Fig. 3) because the plate wall 441 does not define a plate hole 48 therethrough, as mentioned above.

Fig. 6 is schematic in nature because each of the plate walls 44'a-l (Fig. 3) define a multiplicity of perforations therethrough that are preferably evenly distributed. The perforations are not clearly shown in Fig. 6 in an effort to clarify the view, however a sampling of the perforations is schematically represented by dots. In accordance with the second embodiment of the present invention, an acceptable size of each individual perforation is within the range of approximately 0.0625 inches to approximately 0.250 inches. The perforations also generally are so sized and of a sufficient number that each of the plate walls 44'a-l is approximately forty percent open area. Also, the plate walls 44'a-l are acceptably constructed from a material such as, but not limited to, eleven gauge carbon or stainless steel. In accordance with an alternate embodiment of the present invention, the portion of the plate wall 44'l (Fig. 3) that covers the upstream end of the core chamber (for example see core chamber 32 in Fig. 2) is not perforated.

The term "percent open area" as used within this disclosure can be explained with reference to the plate wall 44'. For example, before the plate wall 44' is perforated it is zero percent open, whereas after the plate wall 44' is perforated it includes a multiplicity of perforations such that the plate wall 44' defines an open area. Each individual perforation represents or defines an open area which is representative of the capacity of that perforation to pass liquid, as discussed above. Further, unit areas consisting of a portion of the plate wall 44' can be considered to define an open area, wherein the open area of a unit area is the summation of all of the individual open areas defined within that unit area. For example, if a one square inch surface area of the plate wall 44' is identified before the plate wall 44' is perforated, that square inch surface area is zero percent open. After the plate wall 44' is perforated and that one square inch surface area includes a plurality of perforations therethrough, that square inch surface area is some percent open. If the sum of all of the open areas in that one square inch surface add up to an area of 0.4 square inches, then that square inch surface area is forty percent open. If the entire plate wall 44' is perforated in a

manner substantially similar to that one square inch, the plate wall 44' is forty percent open.

Fig. 7 is an isolated, elevational view of a structural member 50' in accordance with the second embodiment of the present invention. In accordance with the second embodiment of the present invention, the structural members 50' generally are solid and function to both structurally reinforce the filtering structure 28' (Fig. 3) and prevent vortexing. In accordance with alternate embodiments of the present invention, a plurality of holes are defined through the structural members 50'. The holes seek to equalize flow within the filter chamber (for example, see the filter chamber 66 in Fig. 2).

Structural members 50' are incorporated into each of the plate assemblies 42'a-f (Fig. 3). Each of the structural members 50' extends radially from the core wall 30' (Fig. 3). Further, structural members 50' within a single plate assembly 42' are, in accordance with the second preferred embodiment, angularly displaced about the longitudinal axis 34' (Fig. 3) as depicted in Fig. 4. In accordance with various alternate embodiments of the present invention, each plate assembly 42' preferably includes six or more structural members 50' angularly displaced about the longitudinal axis 34'.

Each of the structural members 50' includes an inner edge 54 connected to the internal core tube 26' (Fig. 3), an opposite outer edge 56 connected to the respective outer wall 46' (Fig. 3), a side edge 58 connected to the one plate wall 44' (Figs. 3 and 6), and an opposite side edge 60 connected to another plate wall 44'. In accordance with the second embodiment of the present invention the structural members 50' are acceptably constructed from a sheet of steel such as, but not limited to, a piece of eighth-inch carbon or stainless steel, and structural members 52 (Fig. 2) typically are not employed. In accordance with alternate embodiments of the present invention, structural members 52 generally are employed.

Fig. 8 is an isolated, schematic, plan view of a representative outer wall 46' of a plate assembly 42' (Fig. 3), wherein the outer wall 46' is in an unrolled

and flattened configuration. The outer wall 46' includes opposite short edges 80, 82 that are preferably connected such that the outer wall 46' encircles the longitudinal axis 34' (Fig. 3). The outer wall 46' further includes opposite elongated side edges 84, 86. In a representative plate assembly 42' (Fig. 3), the elongated edge 84 of the outer wall 46' is connected to the outer peripheral edge 47 (Fig. 6) of one of the plate walls 44', and the other elongated edge 86 of the outer wall 46' is connected to the outer peripheral edge 47 of the other plate wall 44'.

Fig. 9 is an isolated, schematic, plan view of a representative inner wall 43' of the suction strainer 20' (Fig. 3), wherein the inner wall 43' is in an unrolled and flattened configuration in accordance with the second embodiment of the present invention. the inner wall 43' includes opposite short edges 88, 90 that are preferably connected such that the inner wall 43' encircles the longitudinal axis 34' (Fig. 3). The inner wall 43' further includes opposite elongated edges 92, 94. With respect to an exemplary inner wall 43', the elongated edge 92 is connected to one plate wall 44' (Fig. 3) while the other elongated edge 94 is connected to another plate wall 44'.

Figs. 8 and 9 are schematic in nature because each of walls 43', 46' define a multiplicity of perforations therethrough that are preferably evenly distributed. The perforations are not clearly shown in Figs. 8 and 9 for the sake of clarity, however, a sampling of the perforations is schematically represented by dots. In accordance with the second preferred embodiment of the present invention, and with respect to the inner walls 43'a-e (Fig. 3) and outer walls 46'a-f (Fig. 3), an acceptable size for each individual perforation is within the range of approximately 0.0625 inches to approximately 0.125 inches. In accordance with one acceptable example, the perforations through the walls 43'a-e, 46'a-f generally are of a size and number that each of the walls 43'a-e, 46'a-f are approximately forth percent open. The walls 43', 46' also are generally constructed, for example and not limitation, from a sheet of metal such as, but not limited to, a piece of eleven gauge carbon or stainless steel. In accordance with

alternate embodiments of the present invention, the walls 43'a-e, 46'a-f are also acceptably constructed, for example and not limitation, from wire wrapped well screen.

Referring to Fig. 10, which is a schematic representation of portion of a BWR nuclear power plant, in accordance with an exemplary application of the preferred embodiments of the present invention, the suction strainer 20 (Figs. 1 and 2) and the suction strainer 20' (Figs. 3 and 4) are preferably connected to an ECCS of a BWR nuclear power plant. Fig. 10 depicts a portion of an ECCS following a LOCA. The suction strainer 20 is submerged in a suppression pool 100, where the suction strainer 20 is connected to the downstream end of a suction line 102 through which an ECCS pump 104 draws water 105 from the suppression pool 100. In one mode of operation (which is generally depicted in Fig. 10), the ECCS pump 104 discharges through a discharge line 106 to a reactor core 108. In another mode of operation, the ECCS pump 104 discharges back to the suppression pool 100. The suction strainers 20, 20' are uniquely constructed and arranged, and operate, such that they are capable of being readily incorporated into, optimize the operation of, and are capable of withstanding the rigors associated with, ECCSs.

It should be understood that the specific construction and arrangements of the suction strainer 20 (Figs. 1 and 2) and the suction strainer 20' (Figs. 3 and 4) are provided as acceptable examples only. The broad concepts disclosed with respect to the suction strainer 20 and the suction strainer 20' lend themselves to a variety of differently configured suction strainers, and configurations will vary depending upon desired flow rates, space constraints, and the hydrodynamic forces potentially applied to a particular suction strainer and the attachment ECCS piping. For example, Fig. 11 is a schematic, side elevational view of a suction strainer 20'' in accordance with an alternate embodiment of the present invention. The suction strainer 20'' depicted in Fig. 11 is substantially similar to the suction strainer 20' of the second preferred embodiment, except that it includes less plate assemblies 42''a-d, and the diameters of the plate assemblies 42''a-d taper. As

another example, Fig. 12 is a schematic, upstream end, elevational view of a suction strainer 20''' in accordance with another alternate embodiment of the present invention. Fig. 13 is a schematic, side elevational view of the suction strainer 20''' of Fig. 12. The suction strainer 20''' depicted in Figs. 12 and 13 is substantially similar to the suction strainer 20' of the second preferred embodiment, except that the suction strainer 20''' includes less plate assemblies 42''a-d, and the plate assemblies 42'''a-d are star-shaped. The plate assemblies 42''' encircle the internal core tube 26'', as is indicated by the broken line showing of the internal core tube 26'' and core wall 30'' in Fig. 12.

10 As an additional example, another embodiment of the present invention includes a convertible suction strainer (not shown) that includes a 170 square foot filtering surface (for example see the filtering surface 40 in Figs. 1 and 2), 13 disks (for example see the plate assemblies 42 in Figs. 1 and 2) that are 40 inches in diameter, and a 24 inch flange (for example see the connection flange 38 of Fig. 1), wherein the convertible suction strainer is 48 inches long from the first to 15 the last disk. The internal core tube (for example see the internal core tube 26 in Figs. 1 and 2) of the convertible suction strainer has large evenly spaced holes therethrough that are not constructed and arranged to control inflow through the internal core tube.

20 The internal core tube of the convertible suction strainer is constructed and arranged to structurally support a filtering structure (for example see the filtering structure 28 in Figs. 1 and 2) that is connected to and extends radially from the internal core tube. The downstream end of the internal core tube of the convertible suction strainer is covered with a perforated plate (for example see the 25 plate wall 44'' in Fig. 3) that can be temporarily opened to provide an opening to the core chamber that is defined by the internal core tube (i.e., the first internal core tube). A second internal core tube is capable of being inserted through the provided opening so that it is installed within the core chamber of the first internal core tube. The second internal core tube is constructed and arranged to control

the inflow of water, in the manner discussed above, such that substantially even inflow is established along the length of the first internal core tube.

A further embodiment of the strainer system of the present invention, indicated at 200, is illustrated in Figs. 14-20B. In this embodiment, the strainer  
5 200 is designed for use in service water intake systems as part of an intake strainer system for screening and removing solid or particulate matter such as leaves, sticks and other debris, and fish, frogs and other aquatic life, as well as the larvae of non-swimming aquatic life such as zebra mussels, mollusks, clams and bryzoa and other unwanted microbiological organisms.

10 The strainer 200 generally includes a substantially cylindrical core tube 201 typically is of an expanded size of approximately 10 to 30 feet in length and 6-12 feet in diameter, although greater or smaller size tubes can be used as desired for a particular flow application. In addition, each of the core tubes generally will be formed as a section of pipe or a tube as part of a strainer module 202 to enable  
15 multiple strainers to be stacked or connected in series as illustrated in Fig. 15, to create an elongated strainer to provide the required surface area and thus the required approach velocities and flow volumes. As illustrated in Fig. 15, the core tube generally is mounted to a suction or intake line 203 for an industrial plant, such as a steam generating power plant or other types of industrial applications.

20 The core tube 201 (Fig. 14) includes a substantially cylindrical tube body 204 having an upstream end 206, downstream end 207 and a core wall 208 that defines an internal core chamber 209 (Fig. 16). A flanged sleeve or coupling 211 is mounted to the downstream end 207 of the core tube 201 and connects to the intake line 203. The coupling 211 mounts the core tube on the intake line with  
25 the internal chamber of the core tube in fluid communication with the intake line as illustrated in Figs. 15 and 19A-20B. A cap 212 (Fig. 14) is generally applied to the upstream end 206 of the core tube 201 so as to enclose the downstream end and thus the internal chamber of the core tube.

As illustrated in Fig. 14, a series of core openings 213 are formed through  
30 the core wall 208 of the core tube 201. The core openings 213 generally are holes



or slots formed at spaced intervals along the length of the core tube between the upstream and downstream ends thereof. The core openings are further varied in size so as to increase in size from approximately 1/8 inch up to approximately 2 inches or greater, from the downstream end of the core tube to the upstream end thereof as illustrated in Fig. 14. The sizes or diameters of the core openings 213 and the length/size of the core tube itself typically are selected to provide a uniform, reduced approach velocity for the fluid flow being drawn therein while still receiving a desired total flow volume therethrough as necessary for a particular intake application.

For example, for a water intake system requiring approximately 200,000 gallons per minute (gpm) with an approach velocity of less than .2 ft./s(.06m/s), the length of the core tubes of each module the suction strainer system will be approximately 20-23 ft. (7.0m) with the diameter of the core tube typically being approximately 96 inches. In such a system, it is also possible to use a single or multiple core tubes to achieve the desired flow volume. It also will be understood by those skilled in the art that the diameters and lengths of the core tubes can be varied as can be the sizes of the flow openings as necessary to encompass a wide range of various size/diameter and length core tubes to produce a desired volume of water flow at a desired approach velocity. By reducing the flow velocity, the strainer 200 thus reduces the tendency for fish, larvae and other aquatic life to be drawn into the suction strainer system and thus into the water intake of the plant.

As shown in Figs. 15-18A, an exterior screening structure 220 is mounted about the internal core tube 201, spaced radially from the core wall 208 thereof. The exterior screening structure generally includes a mesh filter cartridge 221 (Figs. 16 and 18), an intermediate screen or filter 222 and an exterior screen or filter 223. The mesh filter, intermediate screen and exterior screen are mounted in a spaced relationship on a support frame 224 spaced from the core wall. The support from 224 generally includes a series of frame members or structural stiffeners 226. As indicated in Figs. 15 and 15, the exterior screening structure generally is formed in a series of sections or panels 227 that are linked together

along the core tube. Each of the sections 227 generally is approximately a 4 x 4 foot section approximately 4-6 inches thick, although larger or smaller size sections also can be used, and includes a frame 228 that secures the mesh filter, intermediate screen and exterior screen together in a sandwich-type configuration as shown in Fig. 18.

The sections are supported on a supporting frame indicated at 224 (Fig. 16) to maintain the exterior screening structure in a spaced relationship spaced approximately 4 to 6 inches from the core wall. The sections of the exterior screening structure generally engage and lock into place between the frame members with an elastomeric material 229 applied between the support frame members and the frame of each section or panel to help provide a tight but while enabling the sections to be removable as needed for cleaning and/or replacement of the sections 227. Lifting lugs 231 further typically are mounted to the frame of each panel to and in the removal of the panels, and compression latches 232 (Fig. 17) are mounted at the corners of the panels to enable the panels to be locked into and released from the support frame without requiring tools.

As shown in Figs. 16-18, the exterior screen 223 of the exterior screening structure 220 is positioned externally of the mesh filter 221 and intermediate screen 222 facing the direction of the flow of water indicated by arrow "F" approaching the strainer. The exterior screen thus serves as the initial filtering mechanism for filtering out most larger size particulate matter and animal life. The exterior screen 223 (Fig. 17) generally is a perforated plate 235 that typically is formed from a metal material such as steel or from an expanded metal grate and includes a series of flow holes 36 formed therethrough. The flow holes 36 generally are approximately equally spaced across the plate of each exterior screen and are approximately  $\frac{1}{2}$ " to 1" in diameter so that each exterior screen has approximately 50% open area. It will also be understood that the flow holes can be of larger or smaller sizes as necessary to achieve a desired flow rate and flow volume therethrough. It is also possible to use other types of heavy structural screening materials and other types durable, corrosion resistant materials, such as,

other types of metals and possibly some plastics. In addition, the exterior screen typically is coated with a flexible ceramic or other smooth, non-stick coating that inhibits adhesion by microbiological organisms to further aids in the cleaning of the exterior screen to remove collected debris and other matter therefrom.

5           As indicated in Figs. 16 and 18, the intermediate screen 222 generally is mounted internally from the exterior screen 223 between the exterior screen and the mesh filter. The intermediate screen 222 generally is spaced approximately 1 to 2 inches from the exterior screen, with the spacing of the intermediate screen from the external screen generally varying depending upon a desired flow volume  
10           and approach/flow velocity of the water flow passing therethrough, in order to provide a substantially uniformed, controlled flow at a desired volume and/or rate intermediate screen generally is formed from a wire mesh, typically 1/4" by 1/4" with 1/8" wires therebetween to enable the intermediate screen to screen out substantially smaller particulate matter and aquatic life that is larger than  
15           approximately 1/8 of an inch, but which is still able to pass through the exterior screen. The intermediate screen thus servers as a secondary filtering mechanism to further filter the water flow prior to the water flow reaching the mesh filter 221.

          The mesh filter 221 generally is positioned internally of the intermediate screen and serves as the final filtering mechanism prior to the water flow reaching  
20           the internal core tube of the strainer. The mesh filter typically is formed from a non-woven polyester material or similar woven or non-woven fine mesh filter/screening materials and includes a series of perforations 238 that are generally are approximately 80 to 100 microns in size, although mesh materials having larger or smaller size perforations also can be used as desired. The mesh  
25           filter generally is arranged in a folded or pleated configuration forming a series of 8 to 10 pleats 239 per inch of filter material, with each pleat being approximately 4 inches deep.

          For each panel of the exterior screening structure, therefore, there typically would be approximately 4 feet by 4 feet by (4" X 2 rows X 10"/inch<sup>2</sup> of frontal  
30           filter area) so as to provide approximately 1,280 foot square of mesh filter media

area. The number of pleats and the size of the perforations further can be varied as desired to vary the total amount of available mesh filter area based upon a desired flow volume and/or approach velocity to ensure a substantially uniform, controlled flow. The mesh filter 221 serves to filter out larvae such as mollusks, bryozoa and other types of larva, as well as other unwanted microbiological organisms and microscopic matter contained within the water flow to prevent this material from passing through the core tube and into the intake line for a suction strainer system at an industrial plant.

Figs. 17A-17B and 18A-18B illustrate alternative exemplary uses of the strainer 200 for use with a water intake system which draws in a flow of water, indicated by arrows F from a reservoir such as a pond, river or collection basin. The flow of water F is drawn into the suction strainers 200 and 200' and into the intake line 203 by an intake pump 241, which further includes a pump casing 242 that extends from the pump to the end of the suction or intake line 203. The flow of water is drawn along the intake line and pump casing for feeding to heat exchangers, chillers or other applications within a plant.

In the first example application of the suction strainer system of the present invention, illustrated in Figs. 19A and 19B, a pair of suction strainers 200 and 200' are mounted in series extending horizontally. The downstream end 207 of suction strainer 200 is connected to the upstream end 206' of suction strainer 200' to form an elongated strainer system. Figs. 15 and 19A-B illustrate the modular construction of the suction strainer system of the present invention in which the suction strainer modules can be placed end-to-end to create an expanded suction strainer configuration of a size and a diameter adapted to achieve a desired intake velocity and flow volume. To further reduce the intake or approach velocities of the water flow coming into the system, additional modules can be added in further series.

Figs. 20A and 20B illustrate a further alternative example arrangement of the suction strainers in which the suction strainers 200 and 200' (Fig. 20B) are mounted vertically in parallel. In this arrangement, each of the lower or upstream

ends of the suction strainers are connected to a Y-pipe connector 243 that mounts to the intake line 203. The service water is thus drawn into the two strainers and is directed into the intake line through the Y-pipe connector.

The expanded size of the strainers including the use of core tubes having  
5 varying size openings formed therein enables a significant reduction in the approach velocities of the fluid flows being drawn therein, while still enabling relatively high desired flow rates or intake volumes to be drawn therethrough. The reduced approach velocities enable the use of a fine mesh filtering material as part of the exterior screening structure. As a result, the strainers are able to screen  
10 out even small, non-swimming larvae and particulate matter to prevent such larvae and particulate matter from being drawn into the heat exchangers or other systems of the plant through the intake of service water, without the exterior screening structure becoming frequently clogged or blocked so as to require frequent cleaning or replacement. In addition, other types of exterior screening  
15 structures such as stacked disks or other constructions formed from a fine mesh filtering material also can be used.

Over time, as the strainer 200 of this embodiment filters and traps material such as non-swimming larvae and other particulate matter from an intake water flow, this trapped material will tend to build up on the exterior screening structure  
20 on the exterior and intermediate screens and on the internal mesh filter. Some cleaning of this exterior screening structure thus will be required over the life of operation of the strainer. When such cleaning or replacement of a panel of the exterior screening structures necessary, divers can release the panel from its locked engagement by disengagement of the compression latches 232 from the  
25 support frame 224 and attach lifting cables or lines (not shown) to the lifting lugs 231. The panel(s) can then be removed from the water where it can be cleaned and the internal mesh filter media replaced as needed. Thereafter, the cleaned/refurbished panel simply is lowered back into place along the support frame and is secured with the reengagement of its compression locks. This  
30 system thus provides for a quick and easy replacement and cleaning of the

exterior screening structure as needed without a substantial disruption in the operation of the strainer.

Figs. 19 and 20 illustrate still a further embodiment of the strainer system, indicated at 250, for use along a fluid discharge line for filtering discharged  
5 fluids. In this embodiment, the strainer 250 includes a core tube 251, having substantially the same construction as the core tube 201 disclosed and shown in Fig. 14 and as used in the embodiment of the strainer 200 discussed above with reference to Figs. 14-20B.

The core tube 251 (Fig. 21) has upstream and downstream ends 252 and  
10 253, respectively, with the upstream end 253 of the core tube being connected to a discharge line 254 by a flanged coupling or sleeve 256. The core tube 251 further includes a cylindrical core wall 257 (Fig. 22) defining an internal core chamber 258 along the core tube and through which the discharge fluid flows for discharge from the discharge line. A series of core openings 259 of varying sizes are  
15 formed through the core wall 258 being formed at spaced intervals along the length of the core tube. The varying size core openings enable a substantially uniform flow of fluid being discharged therethrough at reduced flow velocities. The diameter/size and length of the flow tube and the quantity, size and location of the core openings formed therethrough will vary as necessary to provide  
20 uniform, non-turbulent flow across the entire length of the strainer in order to achieve a desired flow volume.

An exterior screening structure 260 is received over the core tube 251, extending along the length thereof, as shown in Fig. 19, and covering the core openings. The exterior screening structure generally includes a pipe jacket 261  
25 typically formed from a filtering material such as a fiberglass or similar type of insulation material that is applied in a blanket approximately 1-3 inches in thickness, although greater or lesser thicknesses also can be used as desired, over the core tube. The pipe jacket effectively filters out iron oxide (rust) particles, dirt and other debris from the discharge water and further helps to smooth out the  
30 turbulent flow of the discharge water from the strainer 250.

The exterior screening structure 260 further includes an expanded metal retaining jacket 262 (Figs. 19 and 20) that is releasibly mounted about the pipe jacket 261 and retains the pipe jacket position on the core tube 251. The retaining jacket 262 generally is formed from an expanded, porous metal material, such as a metal screening material having a series of perforations or openings 263 formed therein. The retaining jacket typically is formed in sections 264 that are applied over the pipe jacket 261 and are locked in place with locking clasps 266 to enable the release and removal of the retaining jacket 262 as needed for replacement and cleaning of the pipe jacket and core tube. The perforations formed in the retaining jacket further enable the substantially complete flow of discharge water therethrough while retaining any large particles or debris passing through the pipe jacket. In addition, thicker insulation materials can be used for the pipe jacket and a larger retaining jacket can be used to secure the pipe jacket about the core tube without unduly compressing the pipe jacket. As a result, the present system is able to provide an effective filter for filtering discharge water from a discharge line with the flow velocities of the discharge water being substantially reduced so as to reduce the turbulence of the discharge water flow and enable filtering of all particulate matter such as iron oxide particles for cleaning the discharge water flow without a significant reduction in the flow volume.

While the embodiments of the present invention which have been disclosed herein are disclosed in preferred forms, other embodiments of the method and apparatus of the present invention will suggest themselves to persons skilled in the art in view of this disclosure. Therefore, it will be understood that variations and modifications can be effected within the spirit and scope of the invention and that the scope of the present invention should only be limited by the claims below. It is also understood that any relative relationships and dimensions shown on the drawings are given as preferred relative relationships and dimensions, but the scope of the invention is not to be limited thereby.

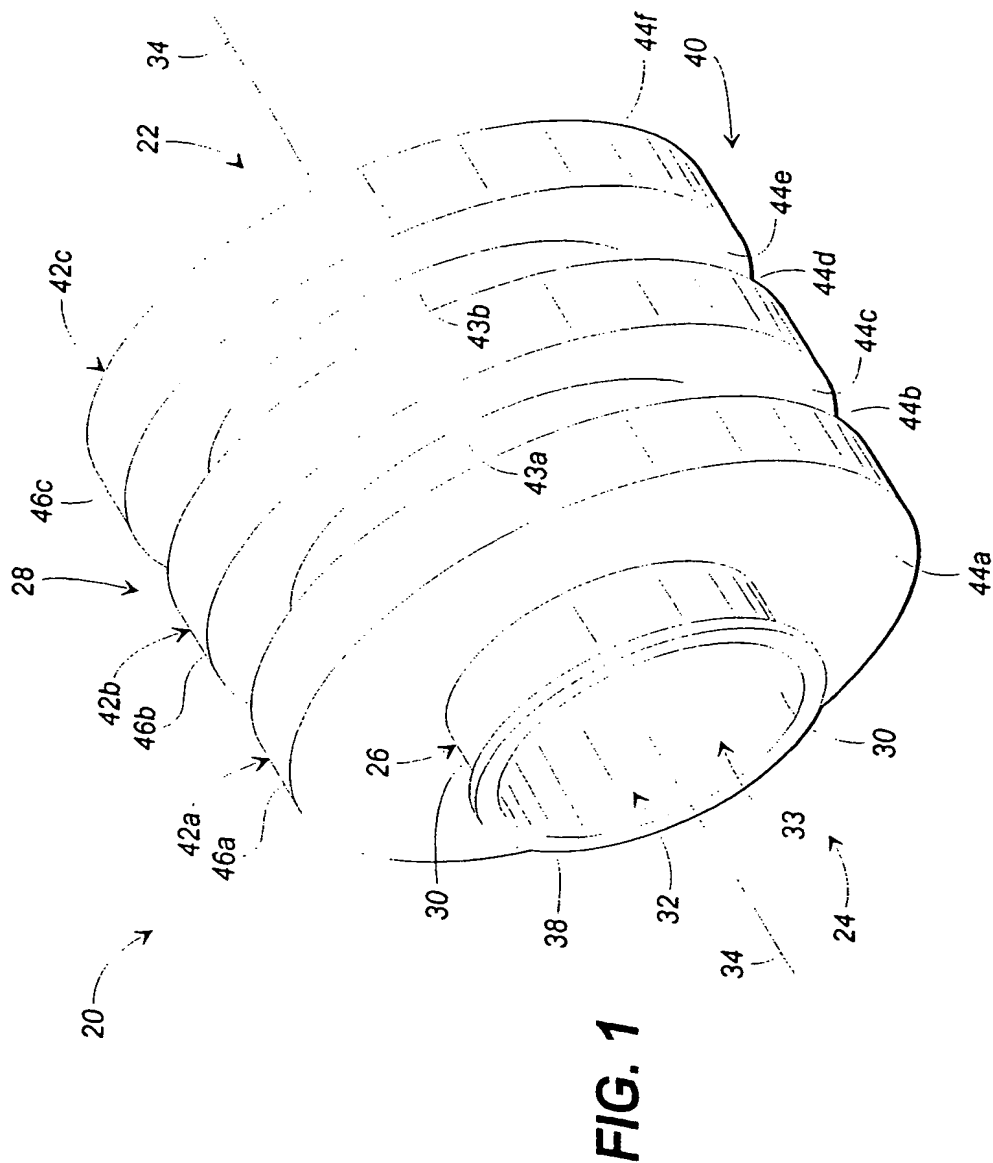
### CLAIMS

1. A flow distribution system for filtering a fluid flow while enabling reduced flow velocities and greater uniformity of flow patterns of the fluid flow, the flow distribution system comprising:
  - an internal core tube including a core wall defining a flow passage and having a plurality of flow openings formed therethrough;
  - wherein said flow openings vary in size along said core tube; and
  - an exterior screening structure received about and supported by said internal core tube, said exterior screening structure including a screening material and a frame mounted on said internal core tube for supporting said screening material in a spaced relationship from said internal core tube.
2. The flow distribution system of claim 1 and wherein said screening material of said exterior screening structure comprises a mesh screen.
3. The flow distribution system of claim 1 and wherein said screening material of said exterior screening structure includes a replaceable pipe jacket formed from a filtering medium and removably mounted about said internal core tube.
4. The flow distribution system of claim 3 and wherein said filtering medium of said pipe jacket includes a fiberglass insulation material.
5. The flow distribution system of claim 1 and wherein said internal core tube includes an upstream end and a downstream end, at least one of said ends being open and communicating with a fluid flow line.



6. The flow distribution system of claim 3 and wherein said exterior screening structure further includes a porous retaining jacket received about said pipe jacket for supporting and holding said pipe jacket on said core tube.
7. The flow distribution system of claim 1 and further including a support frame mounted along said core tube for supporting said exterior screening structure in a position spaced radially from said core tube.
8. A strainer for filtering a fluid flow while enabling reduced flow velocities, comprising:
  - a core tube having an upstream end, downstream end and a core wall defining an internal chamber, and
  - wherein a series of flow openings are formed through said core wall, spaced along said core tube, said flow openings varying in size between said upstream and downstream ends to enable a reduction in flow velocities along said core tube, while enabling a desired volume of fluid flow to be passed through the suction strainer; and
  - an exterior screening structure positioned over and supported on said core tube spaced from said core wall, said exterior screening structure comprising a filtering material for screening solids and particulate matter from the fluid flow, and at least one exterior screen.
9. The strainer of claim 8 and wherein said filtering material of said exterior screening structure comprises a mesh screen.
10. The strainer of claim 8 and wherein said at least one exterior screen comprises a perforated plate positioned externally of said filtering material.

11. The strainer of claim 10 and further including an intermediate screen positioned between said perforated plate and said filtering material.
12. The strainer of claim 8 and wherein said exterior screening structure further includes a replaceable pipe jacket formed from a filtering material and removably mounted about said internal core tube.
13. The strainer of claim 12 and wherein said filtering medium of said pipe jacket comprises a fiberglass insulation material.
14. The strainer of claim 8 and further including a support frame mounted on said core tube for supporting said exterior screening structure at a position spaced from said core wall.



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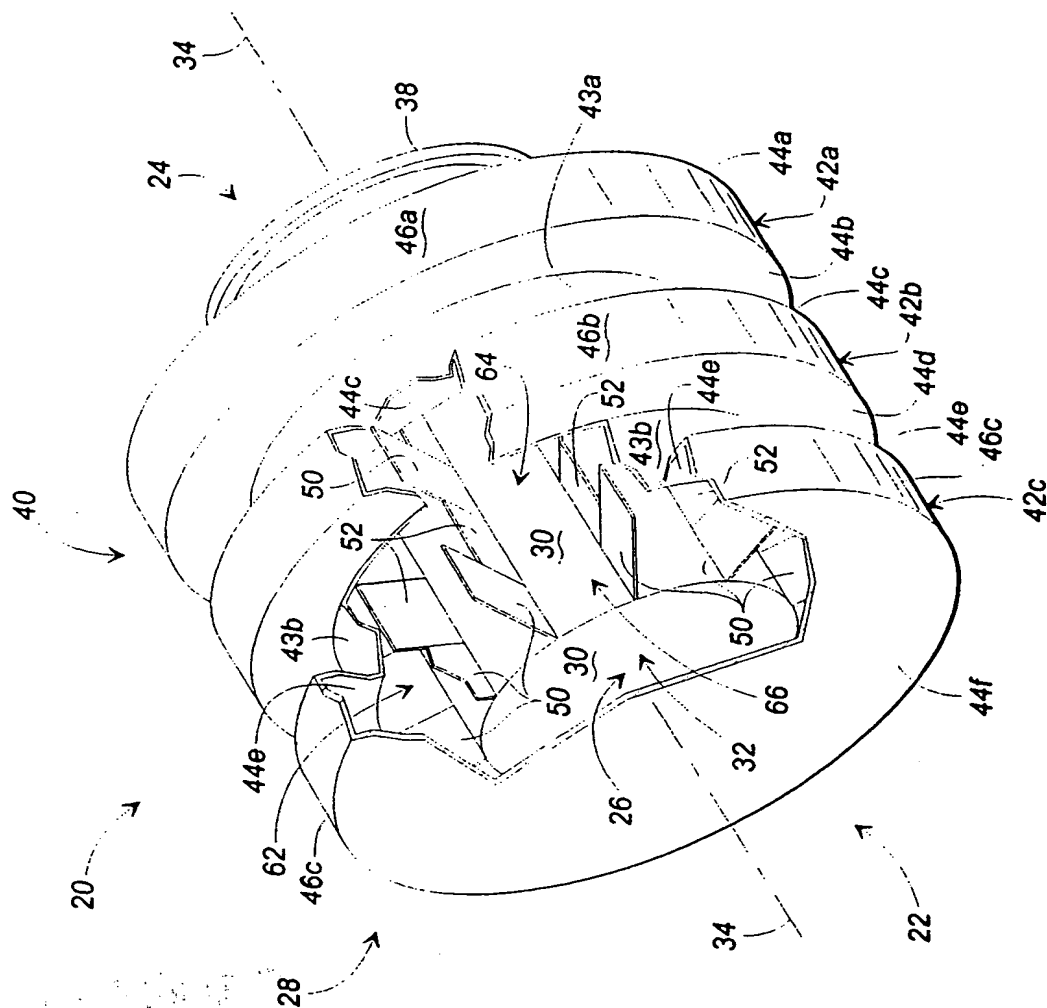


FIG. 2

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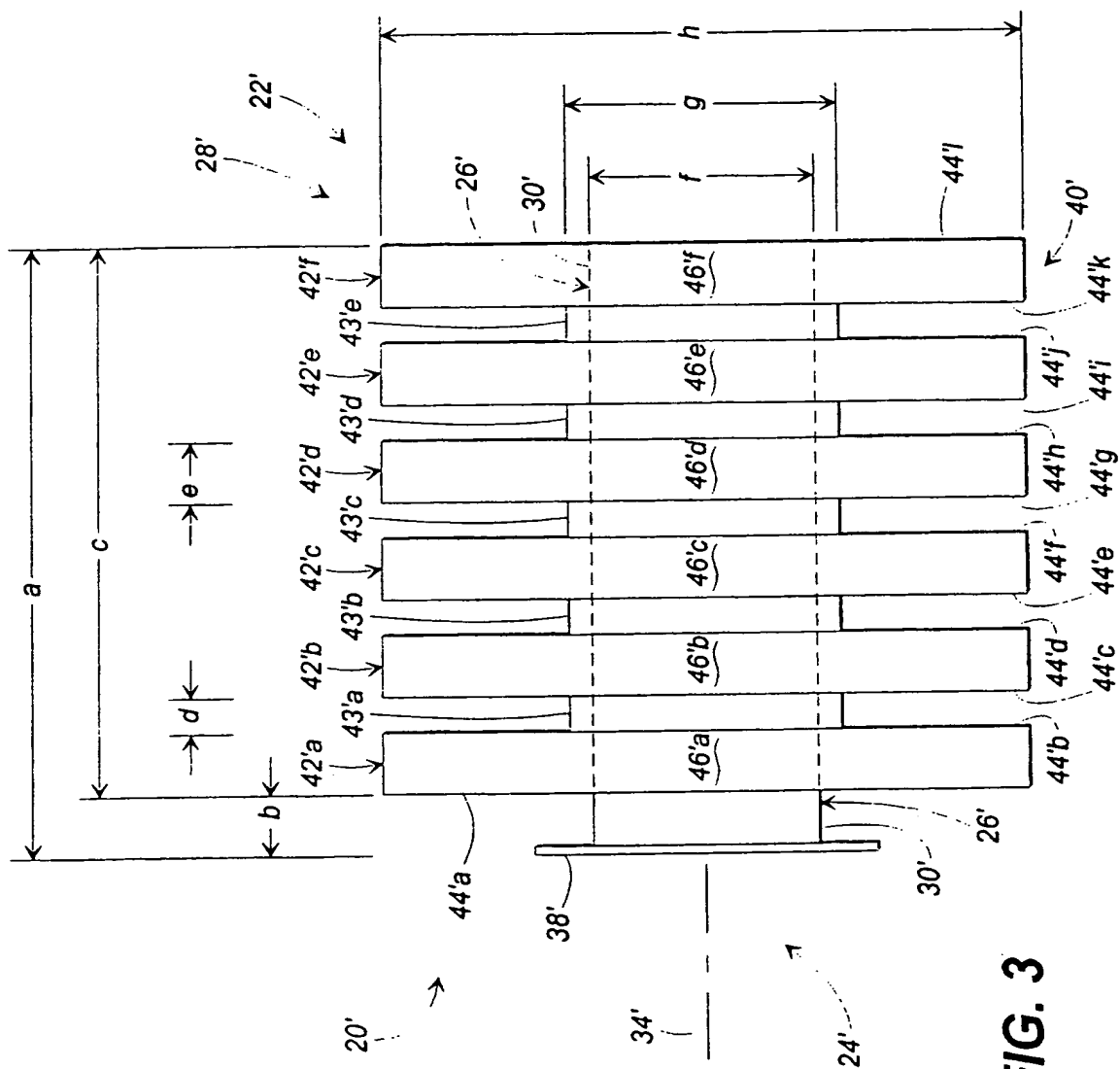
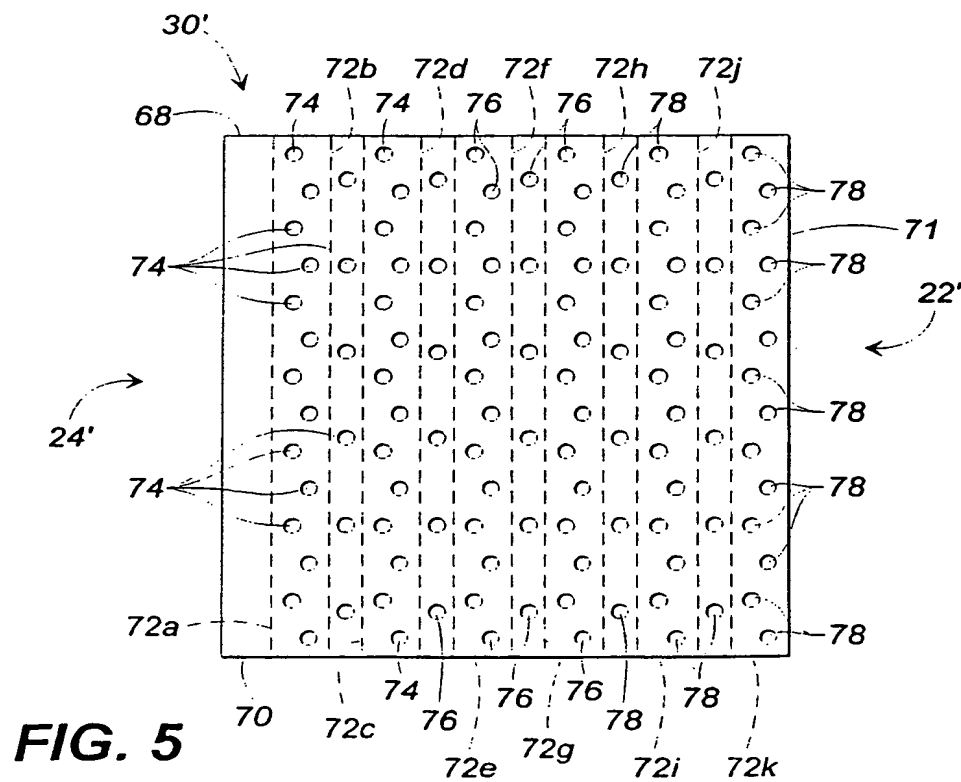
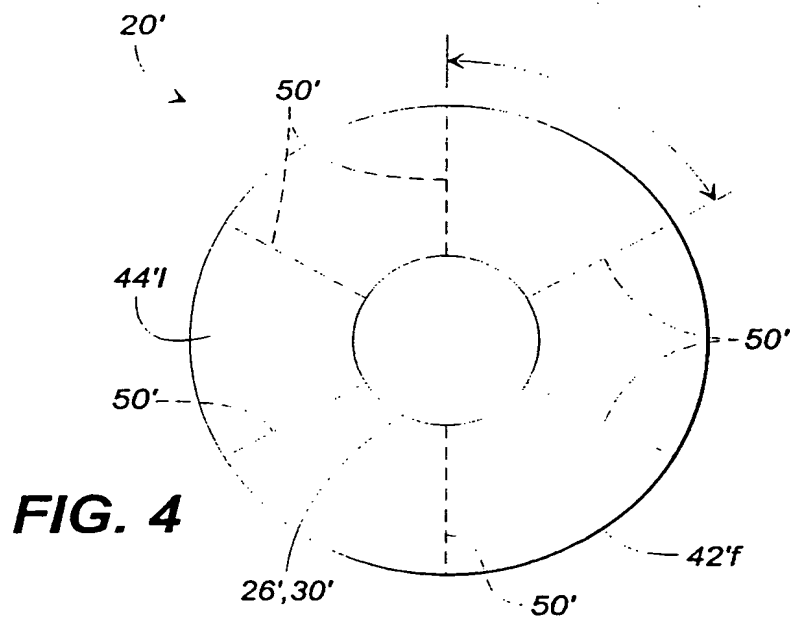


FIG. 3

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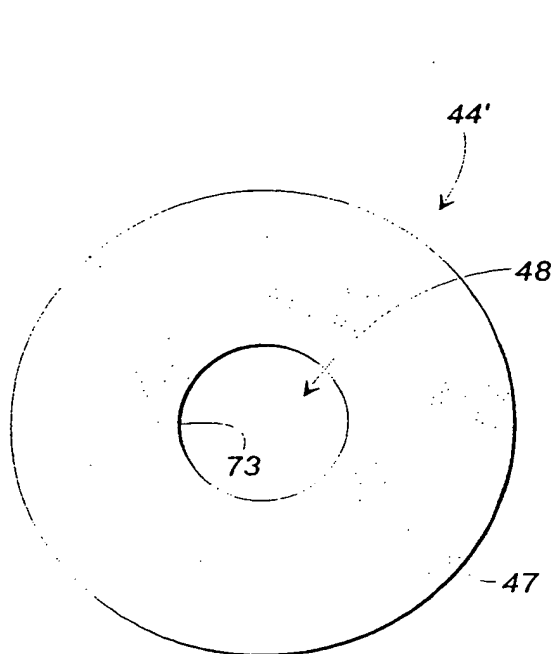


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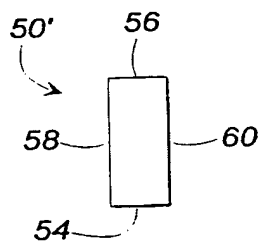


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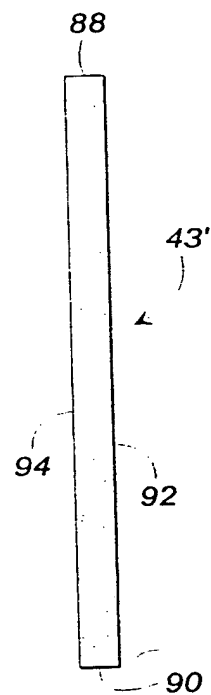
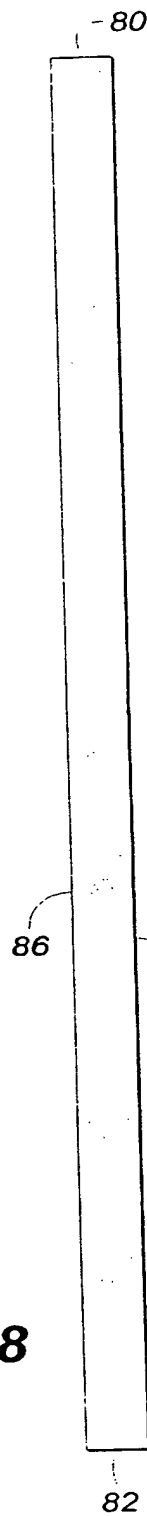


**FIG. 6**



**FIG. 7**

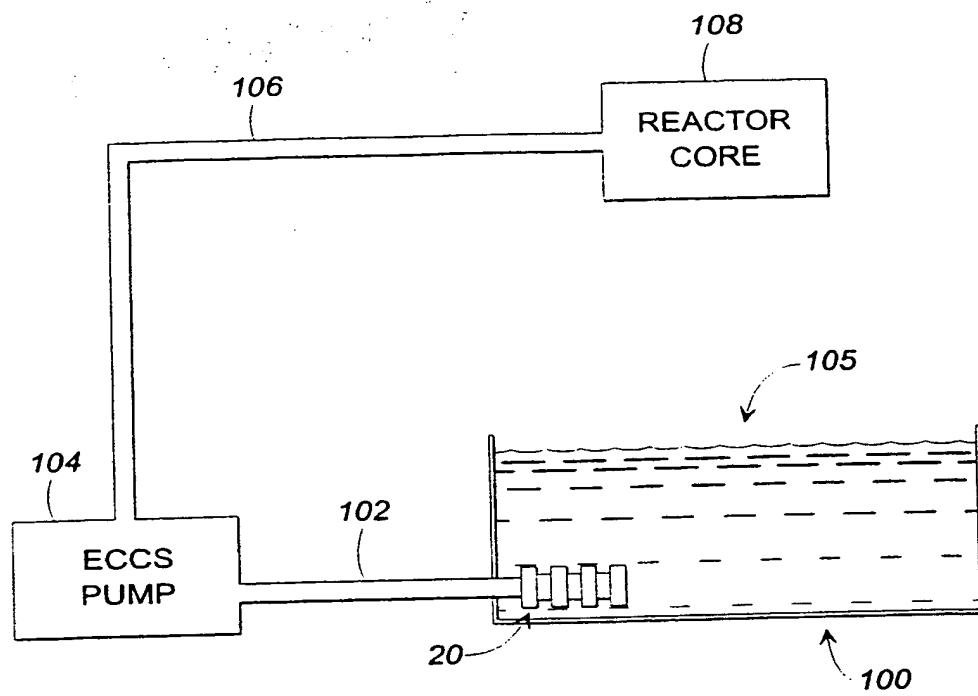
**FIG. 8**



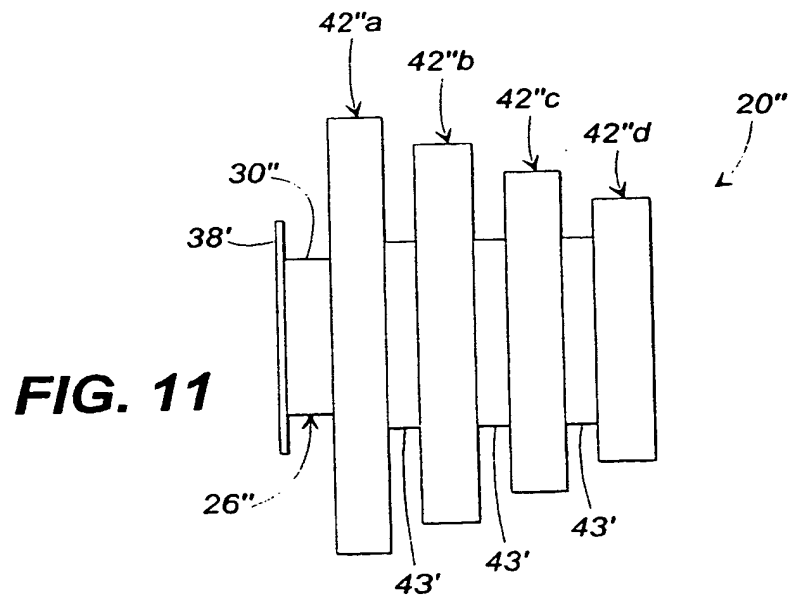
**FIG. 9**

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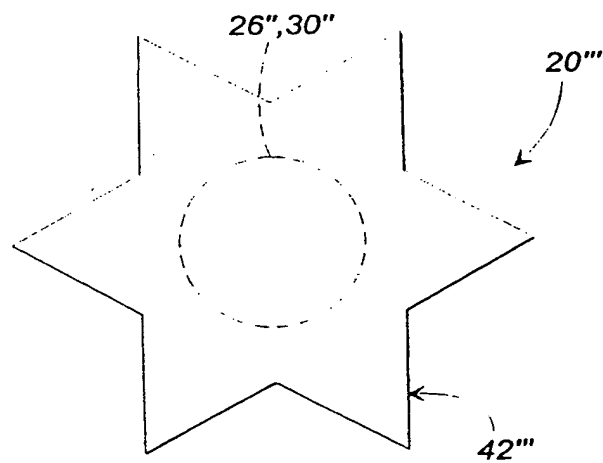
**FIG. 10**



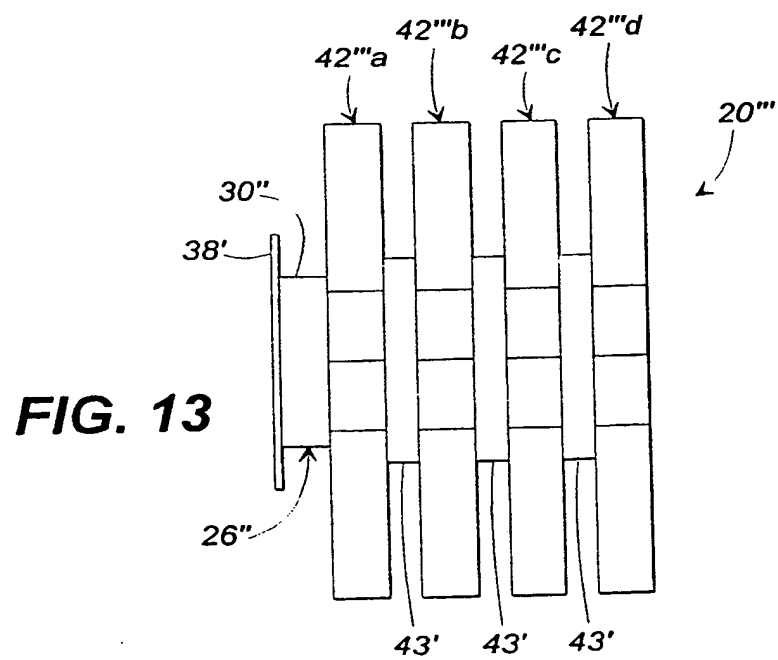
**FIG. 11**

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**FIG. 12**



**FIG. 13**

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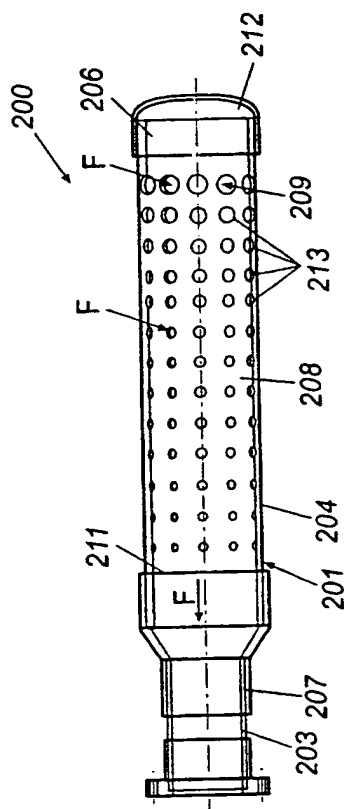


Fig. 14

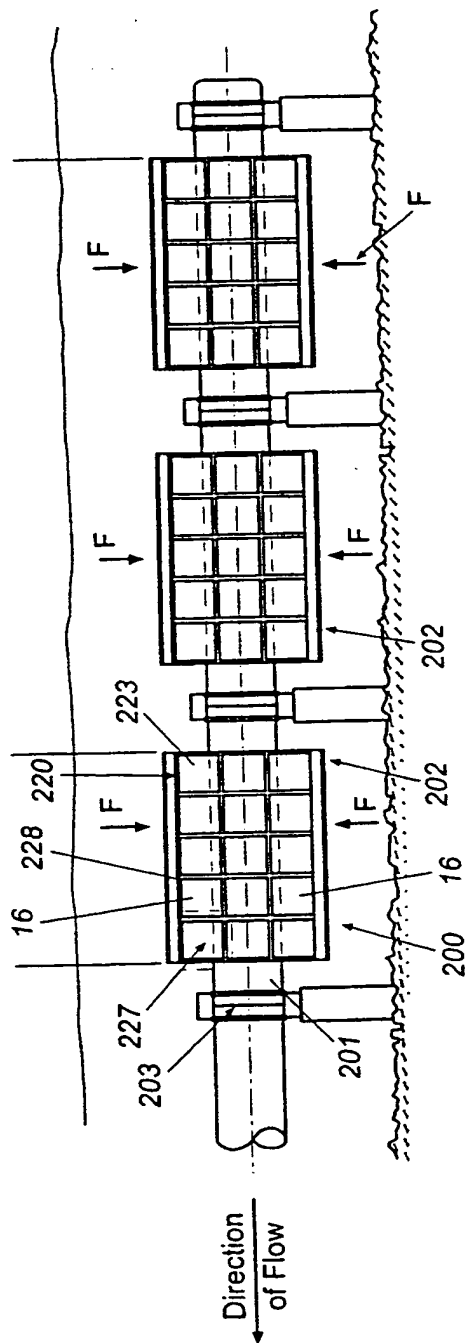
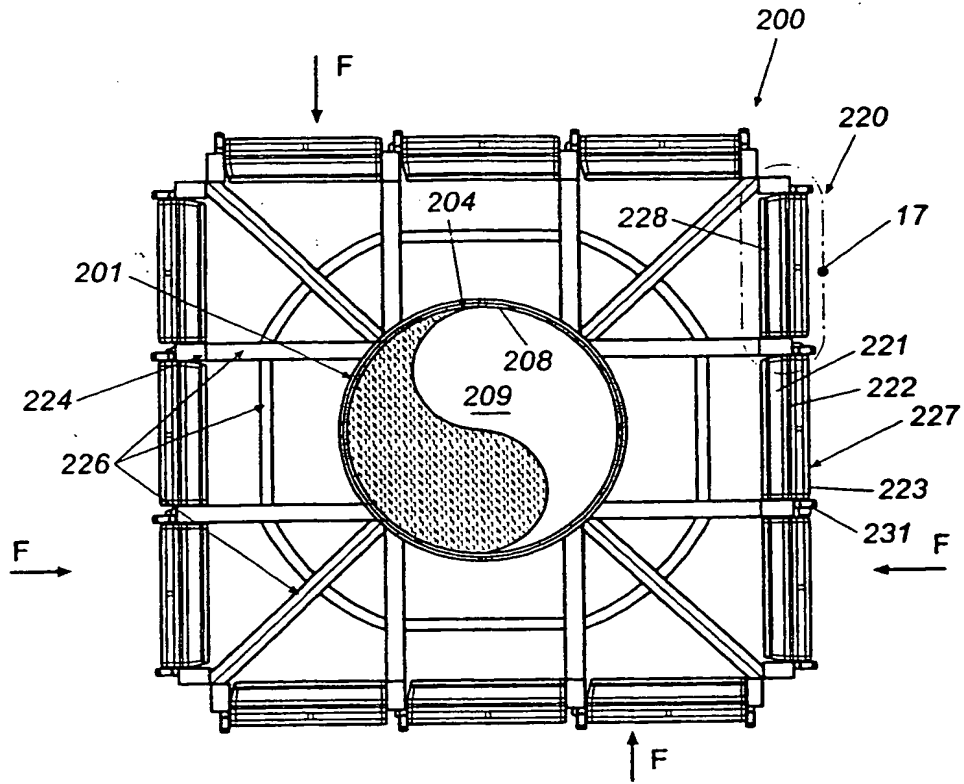


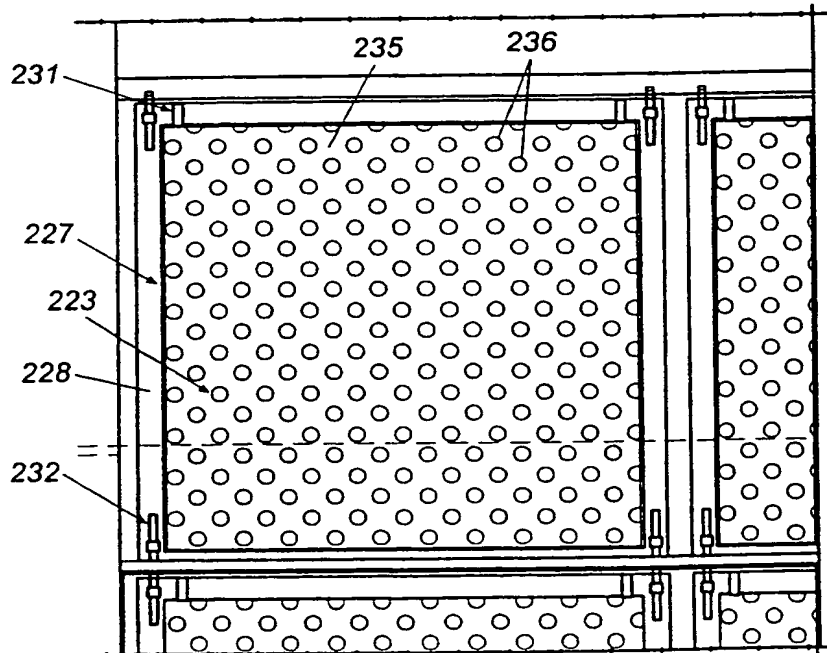
Fig. 15

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**Fig. 16**



**Fig. 17**

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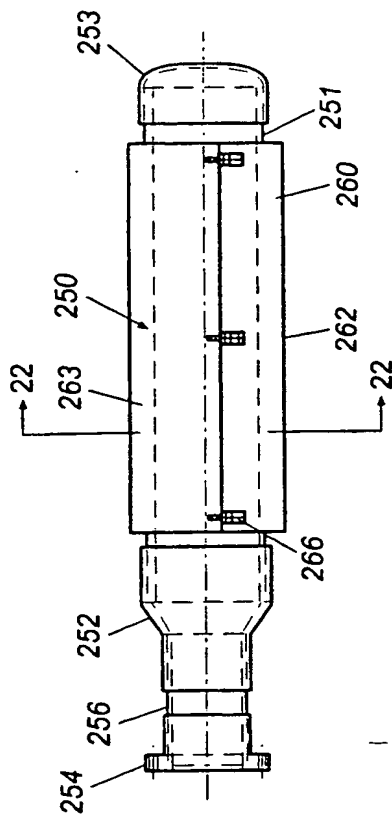


Fig. 21

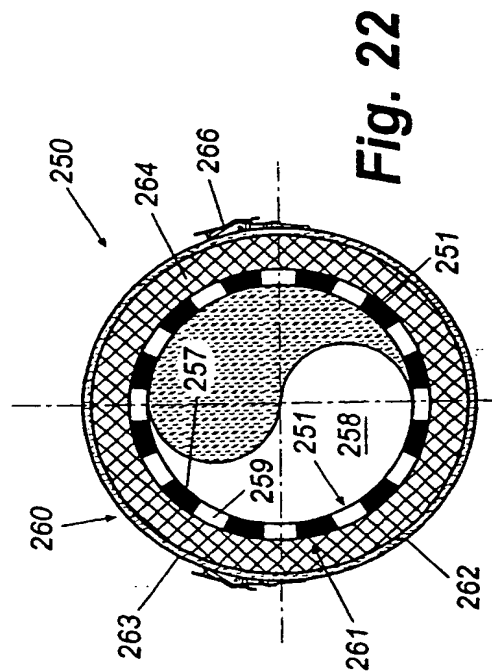


Fig. 22

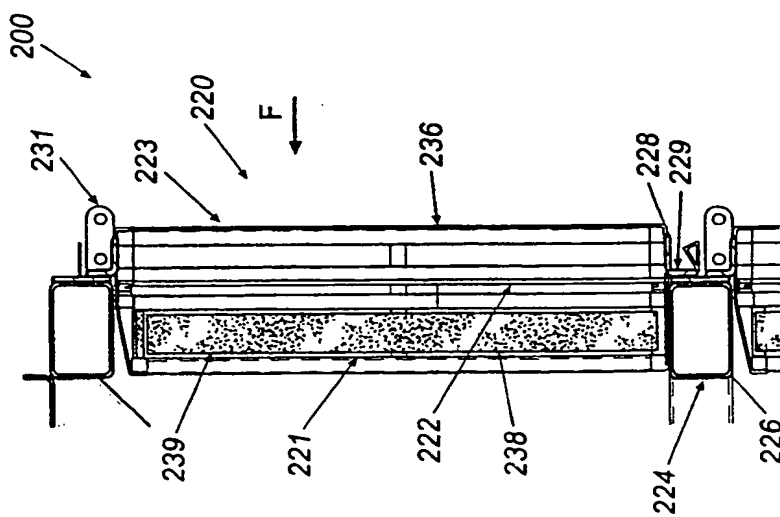
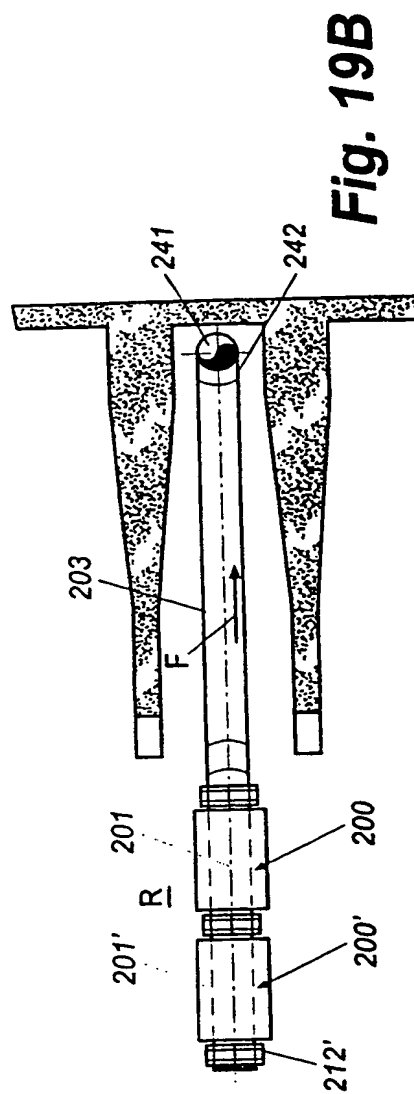
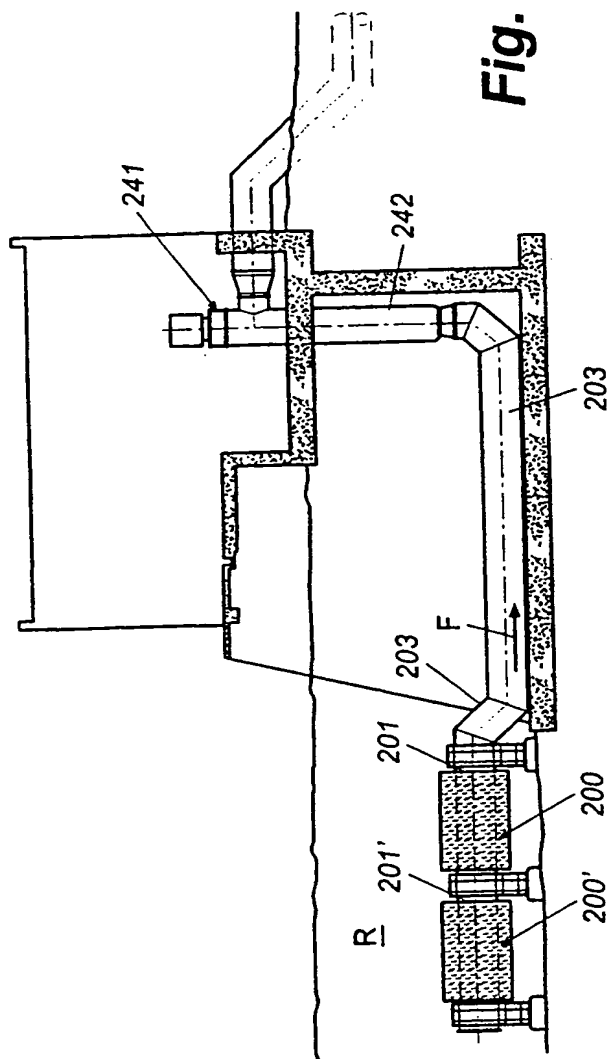


Fig. 18

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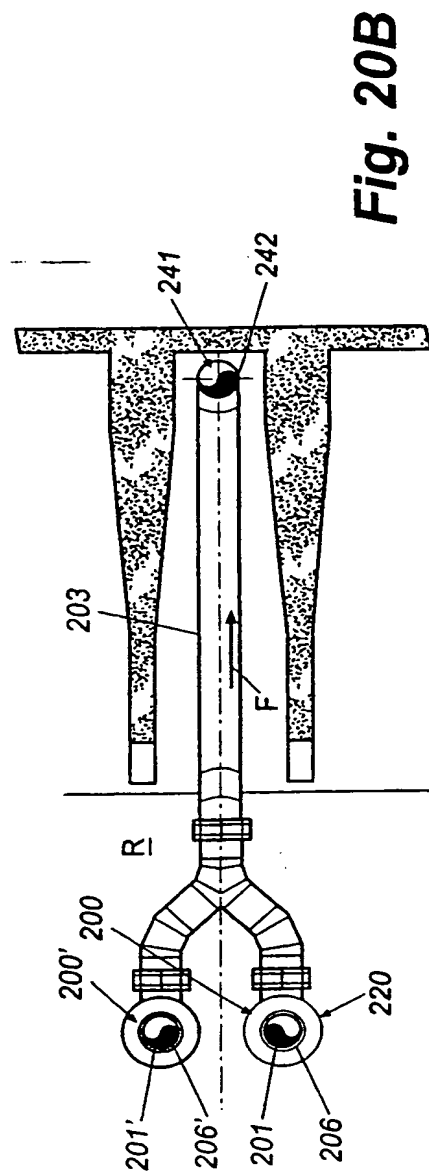
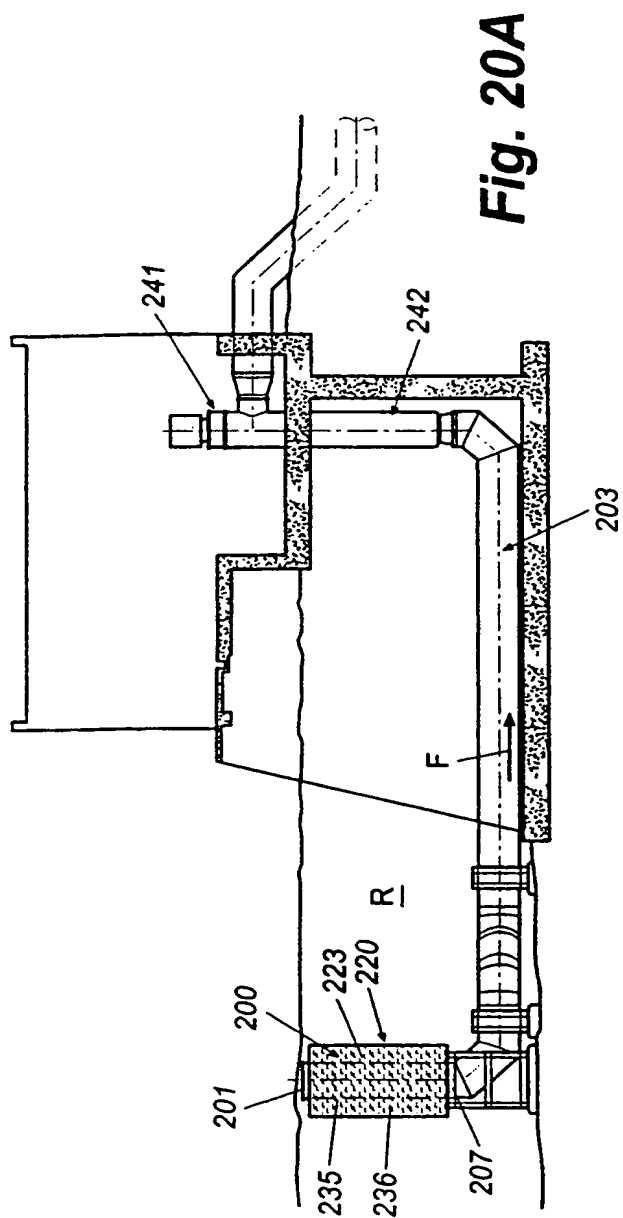
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# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/US 00/31578

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 G21C19/307 B01D35/02

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 G21C B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data, PAJ, EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 843 314 A (HART GORDON H ET AL) 1 December 1998 (1998-12-01) cited in the application the whole document ---	1-14
A	US 5 696 801 A (DWYER ET AL.) 9 December 1997 (1997-12-09) cited in the application the whole document ---	1-14
A	WO 97 36664 A (CONTINUUM DYNAMICS INC) 9 October 1997 (1997-10-09) the whole document ---	1-14
A	WO 98 37561 A (PERFORMANCE CONTRACTING INC) 27 August 1998 (1998-08-27) the whole document ---	1-14
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

8 February 2001

Date of mailing of the international search report

14/02/2001

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040. Tx. 31 651 epo nl.  
Fax: (+31-70) 340-3016

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Deroubaix, P

# INTERNATIONAL SEARCH REPORT

Int. l. Application No

PCT/US 00/31578

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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